

U.S. DEPARTMENT OF AGRICULTURE

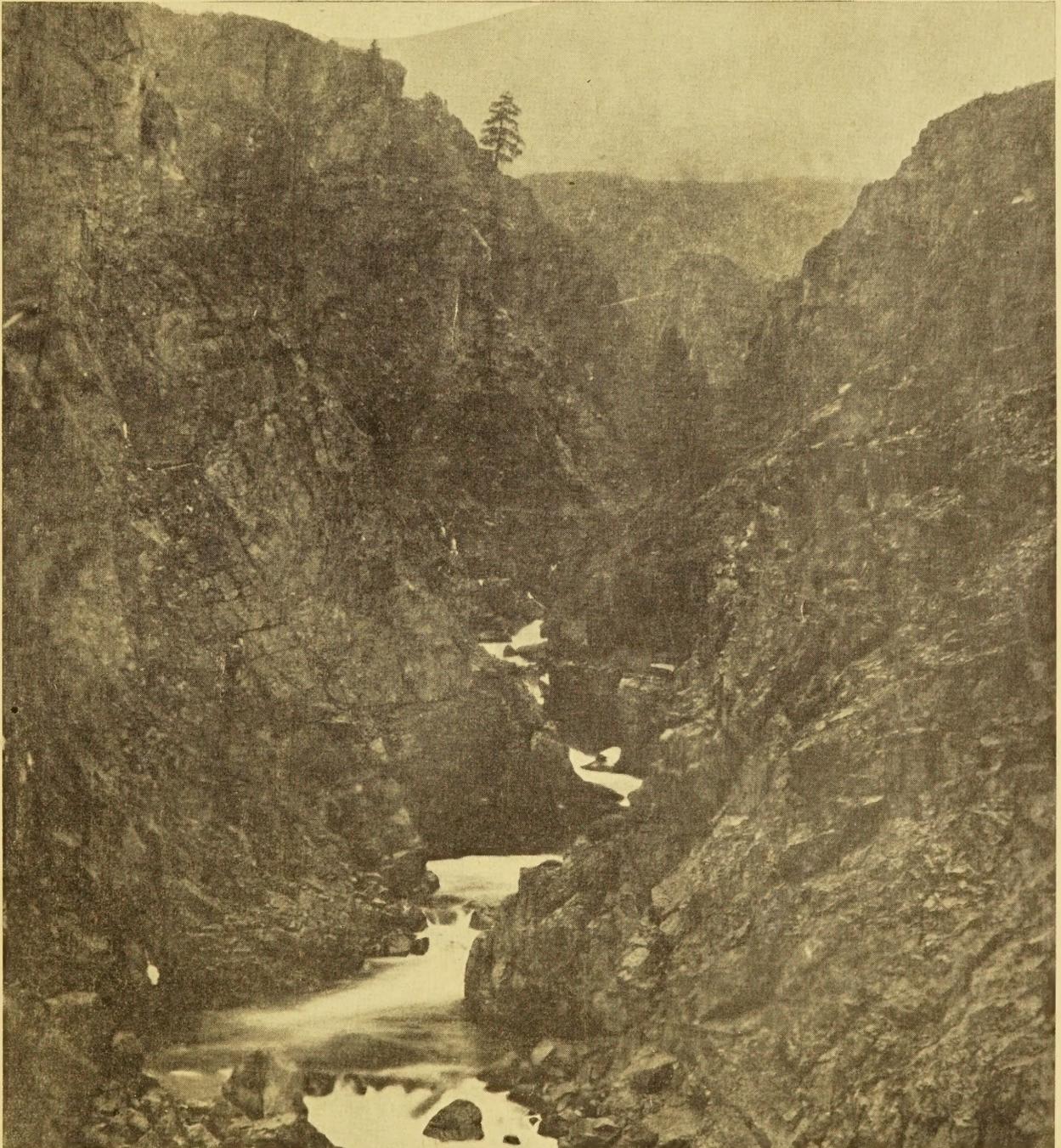
BUREAU OF PUBLIC ROADS

# Public Roads

VOL. 2, NOS. 21-22

WASHINGTON, D. C.

JANUARY-FEBRUARY, 1920



LOOKING UP CHELAN RIVER ON WASHINGTON FEDERAL AID PROJECT NO. 45

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both Houses of Congress. Others desiring to obtain "Public Roads" can do so by sending 15 cents for a single number to the Superintendent of Documents, Government Printing Office, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

TABLE OF CONTENTS

	Page.
Relations of the States with the Bureau of Public Roads . . . . .	3
<i>G. P. Coleman.</i>	
Relations of the States with the Bureau of Public Roads—Discussion . . . . .	4
<i>E. W. James.</i>	
Federal Control and Aid for Highways . . . . .	10
<i>Thos. H. MacDonald.</i>	
Making Highways Ornamental and Useful . . . . .	14
<i>John A. Hazlewood.</i>	
Design of Highway Drainage Systems . . . . .	17
<i>Clifford Older.</i>	
Marking, Signing, and Making Safe a State Highway System . . . . .	20
<i>L. H. Neilsen.</i>	
Maps of a State Highway System for Use of the Public . . . . .	23
<i>M. W. Watson.</i>	
Alignment, Grade, Width, and Thickness in Design of Road Surfaces . . . . .	24
<i>Chas. M. Upham.</i>	
Highway Administration . . . . .	31
<i>George H. Piles.</i>	
A National Program for Highway Research . . . . .	34
<i>Anston Marston.</i>	
Shall Contract Bonds be Eliminated? . . . . .	37
<i>W. G. Thompson.</i>	
Railroad Association Handles Car-Service Problem . . . . .	39
State Testing Engineers and Chemists Meet . . . . .	40
Interesting Federal-Aid Project . . . . .	41
Graphical Progress Report of Federal Aid . . . . .	42
December and January Federal-Aid Record . . . . .	44



THOMAS H. MacDONALD . . . . .	Chief of Bureau
P. ST. J. WILSON . . . . .	Chief Engineer

BUREAU OF PUBLIC ROADS  
PUBLIC ROADS

TABLE OF CONTENTS

ADDITIONAL COPIES  
OF THIS PUBLICATION MAY BE PROCURED FROM  
THE SUPERINTENDENT OF DOCUMENTS  
GOVERNMENT PRINTING OFFICE  
WASHINGTON, D. C.  
AT  
15 CENTS PER COPY



1914

THOMAS H. MERRILL  
DIRECTOR

# RELATIONS OF THE STATES WITH THE BUREAU OF PUBLIC ROADS.

G. P. COLEMAN, Highway Commissioner of Virginia.

WHEN I was asked by your program committee to take this subject I thought it would be advisable to send out a general letter to the various States, requesting them to give certain specific information, and with that in mind, I propounded the following questions:

First. The projects which have been turned down by the Bureau of Public Roads, and their reasons for so doing, with suggestions for meeting these objections and a summary statement including the projects which have been approved.

Second. The objections, if any, which the States have to the law itself, and the rules and regulations of the Department of Agriculture, with suggestions for the improvement of the same.

I have received replies from 28 of the States. These replies have covered such a broad field that I am afraid in dealing with them this paper will infringe on the fields of some of the others.

One thing that has been brought out very positively and clearly, is that the cooperation between the various State departments and the Bureau of Public Roads has improved tremendously in the past 12 months. Mr. MacDonald and his bureau would, I am sure, feel very much flattered and encouraged from the reading of the letters which have been sent in. From these letters I gather the following facts:

## CONCLUSIONS FROM REPLIES.

First. That ninety-odd per cent of the projects which have been submitted to the bureau have finally been accepted, and that in the few instances where projects have not been accepted the bureau has been well within the law and that the States themselves have been satisfied that the decisions were correct. The last amendment to the act cleared up the major difficulties in so far as the post-road feature is concerned, as I have received just one suggestion which merely elaborates on the present law, and which will be covered by question No. 2.

Second. Replies to the second question "Objections to the law itself and the rules and regulations of the Department of Agriculture, with suggestions for the improvement of the same," indicate that, on the whole, the law itself is generally satisfactory. However, there are suggested changes from quite a number of the States which should receive our careful consideration: First, that in some of the States, where the development has not been general and



G. P. COLEMAN.

where the Government itself is a large holder of the property, some amendment should be prepared which would give to the Department of Agriculture, on the request of the State, certain latitude in the expenditure of the State's allotment in excess of the 50 per cent now allowed by the Federal law. If you will make a study of this situation I am sure that you will agree with me that we should make some effort to meet this situation, for some of the States, particularly those just east of the Rockies in the Middle West, will find it difficult, if not impossible, to meet the Federal aid.

It would be advisable for the bureau to establish a different set of standards of construction for both highways and bridge structures for the different sections of the country. The necessity for this is particularly apparent in these sparsely settled communities. It will be readily seen that what would be characterized "as substantial in character" in Nevada would not meet traffic requirements of Massachusetts or New York. It has also been suggested that on particularly long projects some arrangement should be made for the acceptance of these projects in sections. I think, as a matter of fact, that this is largely

covered by the contracts as drawn by the States and can be made without change of the rules and regulations or reference to the Bureau of Public Roads. The Government should participate in the making of surveys, plans, and estimates. This question has been up before the association at various times and there has been a wide difference of opinion, but we have generally agreed that it was not of sufficient importance to ask for an amendment to the law.

It is the general opinion of all of the States that the Bureau of Public Roads has been slow in its acceptance of projects and in paying on the projects.

#### DELAY IN PROJECT APPROVALS.

Delay in approval of projects seems largely due to incomplete understanding by the bureau of the conditions which obtain and to the State department's failure to prepare the plans and estimates as required by the bureau. This situation can, I believe, be very readily cleared up if the bureau will place a resident engineer in each State with instructions to go over the proposed project when the surveys are being made and plans prepared, and the project can then be accepted or rejected on the submission of the plans and estimates, the bureau acting on the recommendations of its engineers. Then any small technical details or defects in the plans and estimates could be cleared up after such acceptance and as the work progresses. This would obviate the delays caused by revisions and the necessary resubmission of plans.

The letters clearly set forth the desirability of such a course on the part of the bureau; that is, placing an engineer in each State, an engineer of sufficient ability to be vested with very broad authority. The State departments are also of the opinion that work would be greatly facilitated if the district engineer was given full authority to pass on all questions other than those of policy. This would undoubtedly lead to a better understanding between the departments and the bureau. It has also been brought out that should this be done it will undoubtedly lead to a better working understanding and the establishment of that confidence between the departments and the bureau which should always exist to accomplish the best results. It is very generally conceded that all of us are anxious and desirous of constructing roads of such type and character as will carry the traffic of the various sections. The signing of the contracts, or agreements, by the highway departments and the Department of Agriculture should be a sufficient evidence of this fact, and therefore the departments, acting with the resident engineer, should be allowed to make such minor changes as the work progresses as may be deemed necessary, without reference to the bureau or being required to resubmit project state-

ments, provided that the costs are kept within the amount of estimates agreed on. To illustrate; it is sometimes advisable to increase the size of a waterway, or do away with others, or change their location. It is also a very common occurrence that a slight change in grade or alignment will improve the general character of the work very materially. All of us can bring to mind many instances where changes could be made to improve our work, but on account of incidental delays they are not undertaken.

#### THE PAYMENT OF VOUCHERS.

Relative to the delay in payment of vouchers which has evidently caused a great deal of concern and some inconvenience to a number of States, I think, judging from my own experience, that this will be largely cleared up as the departments themselves become familiar with the necessary red tape, or routine. I would suggest that the bureau should establish a definite time for vouchers to be received and payments to be made each month, and that vouchers received after that date would automatically pass for payment to the following month. This would then place the burden on the district engineers and the departments.

It is the consensus of opinion that the bureau has been and is unnecessarily technical in the requirements of details for bridges. It is also the general opinion that some arrangement should be entered into whereby the departments would be allowed to begin work before projects are finally accepted by the United States Department of Agriculture. A great deal of delay and unnecessary expense has been caused by the present arrangement. It therefore occurs to me that this condition could be very readily met by the bureau, should it require, first, that the department would take the responsibility for the cost of the work should the bureau finally not approve it, but that the Government would participate to the full 50 per cent should the project be accepted; second, that the bureau should be notified before work was started on the project in order that it might make such inspections as it deems proper.

The bureau could, with very great advantage, revise its rules and regulations and eliminate repetitions and ambiguities. The adoption of these suggestions will do much to bring about a thorough understanding and to advance the big road interest of the country.

The foregoing is largely taken from the representations of the other States. My experience has been most satisfactory. It is barely possible that, as Virginia is a nearby State, the bureau has been trying out the experiment of placing an engineer in the State to work with the department, and it has worked well and has certainly facilitated our work.

## DISCUSSION OF MR. COLEMAN'S PAPER.

By E. W. JAMES Assistant Chief Engineer, Bureau of Public Roads.

It can not but be gratifying to one who has been closely associated, both in technical and executive lines, with the Federal aid road work to have the relations between the Federal Government and the several States in this large undertaking referred to so pleasantly as they have been by Mr. Coleman.

In speaking for the Bureau of Public Roads, I know that I can emphasize the effort that has been made by everyone connected with our part of the work to make the many details of cooperation as clear and as swiftly operating as possible, and just as it takes two to make a quarrel, it takes at least two to establish harmony, and no matter how great our efforts may have been we recognize fully that the States on their part have been considerate, patient and thoughtful to a marked degree in cooperating with us.

### FEW DISAPPROVALS OF PROJECTS.

I shall follow Mr. Coleman's paper closely in this discussion and refer first, as he did, to the few disapprovals which have occurred in the history of Federal aid. Mr. Coleman had no objections to offer and said that the States themselves so far as his record showed were satisfied that the decisions were correct. To this might be added the other side of the matter, that with few exceptions we have known in advance that the States were ready to accept a disapproval before it was made, and in a few cases that information was voluntarily furnished us by the States. In this connection, however, it is very interesting to note that the dire word, "politics," has been associated with only one project that has come under our consideration. The routine of the bureau requires that all important correspondence between the district engineers and the States shall be forwarded to the Washington office for information. This is not an idle regulation because that correspondence is all scanned and some of it read with care. In one of our districts we were able to follow the events in this one case of politics very clearly. The field man had reported to the district engineer that it was quite clear that the location of the road and the selection of the project were entirely influenced by political considerations. The district engineer felt that it was not wise for this statement to appear in the record and informational correspondence which went over my desk indicated that the district engineer had written a short note to this field inspector returning the report and asking him to omit that statement or frame it in some other form. The report of the field inspector reached our office in due course attached to the project in question. Memory came to the rescue. The carbon copy of the informational letter

was dug up and it was found that it applied to the suspected project. Obviously, the project was at once disapproved and so far there has been no aftermath.

Mr. Coleman cites a suggestion made by several States that an amendment should be prepared which would give the Department of Agriculture on the request of the State some latitude in the assignment of aid in excess of 50 per cent now allowed by the Federal law. From the point of view of cooperation between the States and the bureau, Mr. Coleman's suggestion answers itself. The department has neither the authority nor the discretion to allot funds in excess of 50 per cent and the only relief on this point is through Congress.

With respect to establishing different standards of construction for both highways and bridges in different parts of the country, there is this to be said: In the first place, the bureau has gone as far in this direction as it believes it can go under the present law. The large percentage of cheap work is actually in the States where cheap work appears to meet the current highway needs. The requirement of the law is not relative, but precise, and the bureau can not go much further than it has gone in approving the cheaper types of work. In this connection, also, it is interesting and perhaps amusing to note that on those roads which are eventually approved for lower types of construction, the first papers, apparently in an effort to make the road appear important, indicate a traffic which in many cases hardly warrants the construction of the type of road asked. Then when the type is brought into discussion, it is frequently pointed out that after all the traffic is not quite so heavy all the year round as the average cited would make it appear.

### HANDLING WORK IN SECTIONS.

The suggestion has been made that for a long project some arrangement should be made for handling the work in sections. Such an arrangement now exists. It is possible to submit a project statement covering a road 60 or 70 miles long and have it approved as a whole. Later the road may be surveyed, plans and specifications and estimates made for it by sections, and each section or groups of sections in consecutive order or not at the option of the State may be put under agreement. Representatives of the States are referred especially to Minnesota, Illinois, and Georgia, in which States this arrangement is very common. At the present time there is under consideration by the bureau, and it appears now very probable that the bureau will be ready shortly to recommend to the Secretary of Agriculture, an amendment of the Standards Governing the Form and Arrangement of Plans, which will provide for second-class surveys. This arrangement will meet the suggestion of Mr. Cole-

man; not that the Government shall participate in the making of surveys and plans, but that the heavy items of expense, where clearing or new location is necessary, shall be properly construed as a part of construction and paid for as such. This arrangement presupposes the submission of a very simple survey on which approval will be based, and after the project agreement has been entered into the work of clearing may then proceed and complete plans be submitted later before payments are made. It is believed that this scheme will adequately meet the burden of objection to the present expense of some surveys. Figures which have come to our attention from the States of Kansas and North Carolina, and the cost of our own forest surveys, have convinced the bureau that under ordinary conditions the requirements of the present standards governing the form and arrangement of plans are neither onerous nor unduly expensive.

#### SPEED IN CONSIDERING PROJECTS.

The objection raised by most of the States that the acceptance of projects has been slow is perhaps a just one, although it does not seem possible under the present law to quicken it substantially. The bureau maintains the closest control over the field work of the districts through a monthly report and does not hesitate to be critical of its district engineers when the work received from the States is not expeditiously handled. It is a fact, however, that conditions are irregular. In some districts the record is first class and in others not so satisfactory. Our recent monthly reports show that over half of all project statements handled pass the district offices in an average of 5 days. Ninety per cent of the project statements pass the chief engineer's office in 4 days. Of the plans, specifications and estimates, over half pass the district offices in an average of 5½ days and about 90 per cent pass the chief engineer's office in 3½ days. Such delays as have occurred in the handling of plans, specifications, and estimates are the result of differences which are serious enough to be given special consideration. It is a fact which must be noted that the conduct of a project very often looks bad through no fault of the bureau. For instance, we are sometimes at a loss to understand how it is possible for a State to advertise, receive, and open bids, enter into a contract, and begin work before plans are available for our district engineer. This procedure occurs in a very large number of instances. If the plans for the work are sufficiently advanced for the State actually to begin construction, we think that they must be ready for the district engineer in a sufficiently complete form to be passed rapidly to approval. Obviously, no amount of effort on the part of the bureau can expedite the handling of plans which have not been received.

Mr. Coleman's suggestion that conditions will be still further improved, however, by placing a resident engineer in each State is the plan which the bureau has adopted as the probable remedy. In fact, such State representatives have already been placed in States where the work is sufficiently heavy to warrant it, such as New Hampshire, Massachusetts, Pennsylvania, Ohio, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Texas, Arizona, and others. In other districts, men are assigned by the district engineer to cover special States, but do not have headquarters in those States. In this list may be placed Florida, Tennessee, Michigan, Illinois, North Dakota, Montana, Idaho, New Mexico, and California. These men have authority to make the slight changes suggested by Mr. Coleman as desirable. The sizes of waterway, changes in the location of culverts, slight changes in grade and alignment, and even more important changes, providing they do not involve the Government in additional expense, can all be practically approved on the ground by the representative of the district engineer in the State. It is only necessary to carry these matters to the Secretary of Agriculture for approval when the changes are substantial in nature or involve the allotment of additional Federal aid.

#### DELAYS IN PAYING VOUCHERS.

Reference has been made to the delay in paying vouchers. Probably no detail of the Federal-aid work has given the bureau more uneasiness or consumed more time in its adjustment than the matter of vouchering. In the first place, it should be understood that the vouchering under the Federal-aid act is not provided for in the act in detail. It is covered by general fiscal statutes, and disbursements are made through channels in the usual way provided for other expenditures. The act goes no further than to say that such disbursements shall be made through the Department of Agriculture. Therefore, the system of auditing, the form of voucher, the itemized statement of claim, and such details, are all provided for by general statute and it is very difficult to secure any change. Federal-aid vouchers receive the same scrutiny and the same impersonal and routine treatment accorded personal expense vouchers of our own field men. If any of the State officials ever have worked for the Government and submitted vouchers under the fiscal regulations of the Department of Agriculture, it is not necessary to explain to them the minute detail in which all such papers are considered.

Very definite and careful instructions have been issued and the bureau has done everything it can to expedite vouchering and to insure that the States will receive credit for all the items in their claims.

If our instructions are carefully followed, vouchers can be passed rapidly without suspensions, but unless they are carefully followed it is very difficult to explain questionable details to the satisfaction of the auditors. Many of the instructions covering vouchers no doubt appear to the States needless and arbitrary. This is by no means so. For instance, the recommendation as strongly made as we can make it, that all overruns and underruns, and if possible the engineering claims, be deferred until the last voucher is solely made in the interests of the States, at which time these matters can be adjusted so that the States can use the 10 per cent as nearly at their discretion as possible. For, you see, the auditor has ruled that an item once entered as a contingency may never be replaced in the principal estimate. Two final vouchers under the same project agreement are not possible. Therefore, where projects under agreement are sectionalized and the States wish to close out each section separately, we ask them to voucher the sections separately. This and all of the other suggestions that we have made for vouchers are the result of fiscal rulings practically beyond our control, and our whole purpose has been to devise a scheme which, if followed by the States, will give them the least trouble and the freest hand in the matter.

#### AVOID SMALL VOUCHERS.

The last step we took in an effort still further to expedite vouchering was on October 4, when a letter was issued to all of the States requesting that they withhold vouchers until the claim was sufficiently large to require a payment of at least \$1,000 Federal aid. This was done because we found that 35 per cent of the vouchers submitted to the office would involve less than \$1,500 Federal aid and 30 per cent of them involved less than \$1,000. The work of checking and auditing a normal voucher is practically as great for \$100 as it is for \$1,000. So it was felt that considerable relief could be had, both by the States in preparing vouchers and by the bureau in auditing, if the comparatively large number of small vouchers could be reduced. Some States expressed surprise at this request of ours, but it is a fact that we were receiving a considerable number of vouchers involving less than \$250 of Federal aid and we have received them as low as \$142. As a result of the suggestion made October 4, there was relief almost at once, and for this the bureau extends its most cordial thanks to the States. Out of 285 vouchers handled in October, 17 or only 6 per cent were under \$1,000. In November, out of 303 vouchers only 5, or 1½ per cent were under \$1,000.

All vouchers which have been in suitable condition for paying; that is, which have contained no uncertainties about which there has been correspondence, have passed the office in an average of 10 days. This

covers checking, auditing, and all work from the time the voucher is received until it is scheduled to the disbursing officer for payment. It is surprising, however, what a large number of arithmetical errors we find in the vouchers.

#### WORK BEFORE PROJECT APPROVAL.

In connection with the vouchering, as in connection with the handling of plans and specifications, the bureau is sometimes at a loss to understand how it is possible for a State to have the authority to inaugurate construction, proceed for 90 days, and submit three intermediate vouchers, when apparently they have not authority to sign a contract with the Secretary of Agriculture for the prosecution of the work. When I left Washington numerous vouchers were being held on the desks until the execution of project agreements. In one State four or five different projects, involving from one to three vouchers each, were still without executed agreements. Our records show that the project agreements ready for signature were sent to that particular State in July and August, but they had not yet been returned. Of course no payments can be made until the formal contract with the Secretary has been executed.

It has been suggested that the States should be allowed to begin work before projects are finally accepted by the Department of Agriculture. This matter we believe has been pushed as far as it can be under the law. At the present time just as soon as the district engineer recommends that the plans for the project be accepted, the State may proceed with construction. The law as it stands is clear that the projects must be technically approved before, not after, work is done.

The bureau had hoped that the rules and regulations were reasonably clear, but Mr. Coleman suggests a revision to cut out repetitions and ambiguities. The States may be assured that if the rules and regulations are not clear, the bureau will not hesitate, on any of their specific suggestions, to remedy such defects.

These brief references cover the matters raised by Mr. Coleman, but before I conclude, I wish to take up one or two other matters indicating the value of cooperative effort and how it may be still further increased.

#### A STATE DEPOSITORY SUGGESTED.

In the first place, some States could further assist in the operation of the Federal aid law by selecting a State depository. If this is not now possible under the State law, the State highway department might well initiate State legislation providing a remedy. There are still nine States, which is nearly 20 per cent, that use county depositories, necessitating payments directly to county officials. The Federal law specifically permits this condition, but it is not con-

venient and leads directly to difficulties of administration in return for which there are no discernible compensating advantages. There have been some rather amusing incidents which have occurred in these nine States in connection with the county depositories. Not long since one of these unfortunate departments wrote to the bureau requesting revisions of the project agreements on 35 separate projects.

Now the number of revisions to agreements is causing us a great deal of work, much of which we consider unnecessary, and in this particular case there seemed to be no reason which we could see from a distance requiring such revisions. The county was the depository for each project. The State wished to make the State highway department the joint depository to receive only the amounts payable for engineering. A very simple method was suggested by the bureau whereby the State could secure as we supposed the same result much more easily. We suggested that all engineering charges for which the State desired to be reimbursed should be withheld and submitted on a final voucher. In this way all the construction items would be closed out in the next to last voucher and the engineering charges would stand alone in the last voucher. We suggested that an arrangement, which would be entirely satisfactory to us, could be made under which this last voucher would be mailed directly to the State highway department. The voucher payable to the county could then be submitted by the State to the county for endorsement and the State could deposit the warrant to its own credit. Very much to our surprise and somewhat to our amusement the head of the State department replied to us in a letter which aroused our deepest sympathy, saying that he felt very sure that if that last voucher ever got into the hands of the county officials they could never be persuaded to endorse it over to the State highway department. Under the circumstances, we felt that we must go to the trouble of making 35 revisions to help the State department out of its dilemma.

Another interesting case occurred in a Southern State. One day a gentleman called at the bureau with a very confidential inquiry. He wished to know what vouchers had been paid on a certain project. He presented what appeared to be adequate credentials to back up such an inquiry, and in fact he was a lawyer representing certain bond trustees who were handling cooperative funds on the project. Our record showed that a series of vouchers, some half dozen in number, had been paid on the project at regular intervals to the depository indicated in the project agreement. The gentleman returned to his home town and we later learned that the county clerk, acting for the county commissioners who were distinctly hostile in their attitude toward the bond trustees, had in fact received these warrants and placed them to the credit of the county commission-

ers instead of to the credit of the bond trustees. We hope that the bond trustees eventually got their money back.

We are receiving almost weekly, although only nine States are involved, letters either from our district engineers or from the State highway departments asking us when certain vouchers were paid. It seems that the counties receive the Government warrants and either fail to make clear records or fail to inform the States and the States are unable to find out what payments have been made except by coming to our office.

It appears quite clear that considerable jealousy, or perhaps antagonism, exists in some of these nine States between the State highway departments and the several counties, and the suggestion is made that a complete remedy could be had if the State law created a single State depository in all such cases. If the State highway departments could receive the warrants it would seem a simple matter for them to make the necessary payments to the counties.

#### ADEQUATE INSPECTION NEEDED.

There is one concluding matter, that I wish to refer to. I do not hesitate to take it up because I am confident that you will all understand the spirit in which it is done. I know that the representatives of the States concerned will recognize my allusions with both sympathy and entire agreement. Our reports show a decided lack of adequate inspection and resident engineering in many localities. It is by no means confined to the States that use county funds and depend often on county engineers, but the condition occurs occasionally in many different States. One of our district engineers, reporting a State engineer, has said to us that if no more Federal aid is ever voted, the administration of the present law has done enough to raise the standards of engineering, develop specifications, and insure the integrity of construction to make the present Federal aid worth many times the amount apportioned to the State. There are other States where through lack of funds or authority the State highway departments are tremendously handicapped in securing adequate engineering, both with respect to the quality of the personnel and in the mere number of men required. I quote from a recent inspection by one of our general inspectors, referring to a matter which the bureau has advocated from the beginning of Federal aid:

"This is one of the first projects I have inspected in the State where thoroughly satisfactory relocation is being used. The old location, rambling directly up and down hills, with crooked alignment, is frequently abandoned for long stretches of relocation. Mr. \_\_\_\_\_ advised that, rather to the surprise of the highway officials, the new location was found cheaper than the old one. It also proved to be shorter, have much easier grades and better alignment. This improved location is entirely due to the new system being tried

out by the State this year under which all location surveys are to be reviewed with preliminary plan in hand on the ground by the division engineer and one of the headquarters construction engineers before plans are completed."

One of our field engineers, reporting to his district engineer, writes as follows:

"I took the opportunity of checking estimate on revised plans with original estimate in compliance with your request of October 28, 1919, and find a saving of \$12,398.42 as follows:

Saving in excavation.....	\$4,906.20
Saving in rock excavation.....	6,477.90
Saving in borrow.....	1,014.32
	12,398.42

As all projects have an additional 10 per cent added for engineering and contingencies, which would, in this case, be \$1,239.84, we have a total saving of \$13,638.26.

In making these changes the location and grades have been improved and the county and Government have been saved \$13,638.26 through a careful study of the ground with plans in hand."

It would be possible to give many, many pages of such comment, but it is unnecessary to do so. You all in your respective States know the conditions even better than we do, and I will close my discussion by assuring you that the Bureau stands ready to do everything it can to assist where your engineering forces are weak, to make allowances in conditions of emergency, to adjust specifications so that they will harmonize with the abilities of your local contractors, the qualities of your local materials, and the general State practice in road construction. We recognize that the justification of the whole Federal aid program, nation-wide in its scope, depends first of all on successful road building, and to this end we are prepared to cooperate with the States to the fullest extent.

#### GENERAL DISCUSSION OF PAPER.

T. J. EHRHART, state highway commissioner, Colorado: Let me speak of just two points that trouble us in Colorado in connection with our duty to the Bureau of Public Roads. With one we have already had to deal and one we can see we shall have to face in the future. Speaking first of the latter, all our funds are dependent on incoming taxes and we can see with our program there is a possibility of our not having funds enough on hand at some time, perhaps in this coming year, to meet the payments for the projects that are contracted for and on which work is being done. There is probably not more than \$250,000 to our credit in the State road fund. We are paying out as much as \$200,000 in a single month. Our funds for 1920 will not begin to come in until about the 1st of February. We can see that before the year 1920 comes around we might be in a position where we would not have money enough in our Treas-

ury to pay the monthly estimates on the different projects at stake.

The other thing that had caused us a good deal of trouble already, and I presume every other State has to contend with it, is the advancing cost of material.

#### NEW MEXICO'S SITUATION.

L. A. GILLET, state highway engineer, New Mexico: I want to outline the problems the so-called public-land States face. Great portions of our lands are owned by a poor landlord—the United States Government. I will cite our own State, by way of example, because I know more about it. You must understand that New Mexico has practically 90,000,000 acres of land, only 365,000 inhabitants, and an assessed valuation, on the 100 per cent basis, of some \$365,000,000. Practically 45 per cent of our lands are owned by the Federal Government and are not subject to taxation.

At present we have practically no roads, no built roads, I mean; but we are starting out bravely to build a system of 3,000 miles of primary roads, most of which are to be surfaced with gravel. Ninety per cent of this primary system is laid along lines of road which are used by travelers in passing through the State from other parts of the South and Southwest. Federal-aid money is going to be spent on that system.

We are already taxed almost 2½ per cent on the actual valuation of our lands to meet our general expenses, and the last legislature added 4½ mills on the dollar for road purposes, a tax which came within our constitutional limitation. But even that will not meet the full allotment of Federal money that is offered.

I submit to you that—building roads as we are, over 45 per cent of Federal lands from which we derive no benefit by taxation—it is not fair that we should be required to pay 50 per cent of the cost of such roads in order to meet Federal aid. We can not do it.

To illustrate the difficulty of our position let me cite the example of one county in our State. It is 150 miles long, and 90 per cent of the lands in it are Federal owned and yield not 1 cent of return in taxation. Just consider that problem for a moment. In that county, which is sparsely inhabited, the 4½-mill tax (which is a continuous tax) only yields \$16,000 a year to apply on roads. It has one through-line road which is 115 miles long. Figure that out for yourself. The available funds are not sufficient for maintenance.

That is the reason for the resolution as to public-land States. It affects my State and the others of the 17 public-land States. We are asking that our proportion of participation be reduced; not for more than our percentage allotment. But we certainly do want to protect ourselves to the extent that we will be able to use all of the allotment and put it on this main-line system.

# Federal Control and Aid for Highways— Its Results, Merits, and Limitations.

Thos. H. MacDonald, Chief United States Bureau of Public Roads.

A CAREFUL definition of the problem set up by this topic is essential to its discussion, and such a definition rests entirely upon a careful scrutiny and analysis of the uses which we are now making and which we will make in the future of our highways.

These uses may be defined roughly in four general classes: First, those uses chiefly related to agriculture; second, those which are recreational in character; third, those which are commercial; and fourth, those which are military. It is believed that these uses are placed in the order of their importance as determined by their respective volumes, considering traffic in the aggregate for all of the 48 States. Admittedly, there are sections, perhaps of some considerable area, in which the ranking order of these classes would be changed, but conceding this it does not modify the principle that the roads which we are building must serve these four classes of traffic, and that a failure to provide adequately for any one of these classes means a shortcoming, at least, in the methods adopted by both the States and the Nation; so those laws which we now have must be judged in the light of the degree to which we are now providing, or, if given sufficient time, will provide, for these classes of traffic; and certainly provision for these classes is the whole object of the enactment of either State or National highway laws, or the establishment of State or Federal highway departments. This statement should be reiterated until the attention of road builders is focused upon the proper objective. It sometimes would seem that we are likely to lose sight of the object we are attempting to obtain in discussing the manner or the means through which we shall operate, and at such times it seems highly desirable to analyze in some detail the uses of the roads for which we are attempting to provide.

## THE SERVICES OF THE ROADS.

The first class—those uses related to agriculture—includes the town-to-farm and farm-to-town traffic characteristic of the more purely agricultural districts, the country-to-city and city-to-country traffic, which is fast-growing and highly important where adequate roads have been built radiating into the country districts from the large centers of population, and the traffic carrying crops or food stuffs from productive areas which are isolated from rail transportation. Under this class should also be included the social, educational, and religious activities which

produce traffic from the farms to the schools, to the churches, and to the community centers.

The second—the recreational class—includes two distinct types of traffic, local and tourist. Local recreational traffic is continuous, and is not definite in its character. The automobile has been the means of combining a great deal of business and pleasure, and of the two kinds of recreational traffic the first is far more important, because it affects so much larger a percentage of our population, and the recreational value of the continuous outdoor driving, and the increased social intercourse which has resulted, can scarcely be estimated in their effect upon a large percentage of the population, whose social and recreational activities up to the advent of the moderate-priced motor car were very limited.

The tourist traffic is a growing and highly important one, and this growth should be enlarged by providing adequate roads, so that interstate and transcontinental traffic will be encouraged. There is not a single State in the Union that does not possess a locality of interest to the population both within and without the State. There is perhaps no better way to promote a broad Americanism than to make it possible, through the building of roads, for the people of one State to know in a more or less intimate way something of the worth and beauties of the neighboring States, and this interest and knowledge should be sufficiently extensive to take in the National parks, forest areas, former battlefields, and the many points which, through historical association and tradition, or because of their natural characteristics and environments, hold much of value to every man who places his country above all others. While traffic that may be included under the term "tourist" is fast growing, it is very small in comparison to the other recreational uses that are being made of the roads, and it is impossible not to foresee that this class can never be more than a minor percentage of the local recreational use of the highways. During the season of 1918, 54,596 private automobiles entered the 11 National parks, while during the same season approximately 450,000 people visited these parks. These figures may be taken as indicating something of the tourist travel by highways when it is considered that a large amount of our western automobile travel makes the National parks its objective; but considering that this traffic is spread over a period of several months, it will be seen that if all of the automobile travel were confined to a single road, it would then only equal a daily

traffic equal to that on many country highways outside of the influence of any large city, and would not begin to compare with the traffic on our heavy-traveled thoroughfares in populous districts; but considering that the total number is spread over many western roads, it will be seen that this traffic is only incidental to the local uses which are made of the main thoroughfares.

The third class—the commercial use—is not strictly defined by this term, but as used in this discussion refers to the traffic on the highways resulting from the transportation of commodities between centers of population as differentiated from the collection of crops and distribution of commodities in the rural districts. This class of traffic would cover the carriage of commodities, much of it in package form, which now makes up the bulk of short-haul freight and express. No doubt there will be a very large increase in this class of traffic on the highways, but the traffic which developed during the war is not normal and will not continue as the normal conditions reassert themselves. Just what will be the length of haul which, because of its economy, will go to the highways, has not yet been determined, but the only studies made by the bureau, and these during the period of the war, indicate that 100 miles seems to have marked the limit of such hauls. Even conceding that this class of traffic will develop very largely, it must of necessity be confined to those areas where the terminal points, consisting of comparatively large centers of population, are close enough together to allow at least daily one-way trips of the unit of transportation used, and our studies indicate that the limit is being reduced to perhaps 50 miles. It is not intended to overemphasize this limitation and is useful here only to point out that such studies as have been made up to this time indicate this fact.

The fourth—the military uses of the highways—is given fourth place not because of its lack of importance, but because the probable strictly military significance of the highways has been very considerably misunderstood. Any system of highways which will serve the first three classes of traffic will adequately serve the military requirements except in certain particular areas. In such areas the highways must be provided which are demanded by the military authorities as a part of their plans for their military operations, but it must be accented that military highways as such are confined to restricted areas, and, outside of these so-called vital areas, any system of highways that adequately serves the agricultural and commercial traffic will serve also the military purposes in either war or peace times.

#### LARGEST USE OF ROADS LOCAL.

If, therefore, it is conceded that practically all of the traffic which we are now carrying on the highways has been defined in the foregoing classes, it is at once evident that, with the single exception of tourist

traffic, the uses of the roads are largely local. There are no traffic counts which have been made sufficiently extensive to indicate that a general statement may be made that will correctly represent by percentages the use of the roads that is local, but those traffic counts which have been made would place this use as high as 90 to 95 per cent, and it is very questionable if this percentage will decrease very materially even as the roads are improved, for, although the total traffic on improved roads increases rapidly, it is doubtful if the average daily local traffic will fall below 90 per cent, except on those roads which, because of their particular location, are built primarily for tourist travel.

These statements, it must be remembered, are intended to be very general in their character, and to cover the country as a whole, but it must be conceded that more than 90 per cent, and possibly more than 95 per cent, of the demand for better highways arises from the local need for such improvements. The developments of a national highway system must therefore take this fact into consideration, as opposed to the development of a system of national highways. There would be no advantage gained by considering the local uses of the roads as secondary. No plan of administration predicated on such an assumption can prevail, because it is an economic fallacy. That there is a demand for better facilities for tourist travel there can be no doubt, and that there is an increasing demand in localities for better facilities for through transportation of commodities is equally apparent, but that these needs now justify national intervention solely in their behalf or that they are of such a nature that they can not be met by a properly planned national system of highways is open to serious question.

There is no evidence of fact shown by traffic counts, or any highway use of importance, that justifies a presumption that a need of national consequence is being overlooked. Now that we have the public support of a program of expenditures that will enable every highway building organization to proceed as rapidly as the material resources can be developed, we must meet in the development of our highway systems the economic needs of the Nation for highways in the order of their importance. That these highway systems must be laid out along sane and sound economic lines is all the more important when it is evident that such a procedure will eventually produce systems of highway suited to the special needs of each locality, and yet be entirely adequate to meet all the requirements which those who are particularly interested in a system of national highways specify.

#### ROADS AND FOOD DISTRIBUTION.

At the present time there is no more important problem confronting the American people than that of increasing the comfort and desirability of rural life,

thereby stimulating the production of food products, and of equal importance to this is the necessity for providing better methods of distributing food products, and especially the perishable food products, to the consumer without loss of time and without these products passing through so many hands between the producer and the consumer.

Federal intervention through Federal aid, if of assistance toward these ends, is reasonable and proper from such standpoints alone; indeed, such intervention may be said to have become imperative. The city population of this country has for years been growing rapidly, while the growth of the rural regions in many places has been negligible, and too often has been actually negative. The towns have held too many attractions in the way of social, recreational, educational advantages, but through the use of the motor car in conjunction with improved roads, these advantages in favor of town life can be largely overcome.

Beyond any doubt the war accentuated the need for more and better highways during the period of rail congestion, but if there is one need that the after-war conditions have brought close to every individual in the Nation, it is a need for an adjustment of conditions that will allow people to be properly fed and clothed within the limits of their incomes; and so far as improved highways will help to accomplish this, they certainly will be held to fill a great national need. The population of the country has more than doubled since 1880. At that time only a little over 30 per cent of the population was recorded by the Census Bureau as urban, or some 16,000,000 out of a total population of 50,000,000. Today out of a total population of approximately 105,000,000, about half, well over 50,000,000, are urban dwellers. The effect of this condition is reflected in production figures. In 1880 the production of wheat was about 450,000,000 bushels per year, while during the period prior to the war it was only slightly over 700,000,000 bushels. Similarly, in the case of corn, the production in 1880 was about 1,700,000,000, while prior to the war it was about 2,500,000,000. War conditions as to production were abnormal, so prewar figures have been used instead of the later figures. From these figures it appears that the production of food has increased about as the rural population has increased. It is true that there has been some gain in the production of the individual on the farm, but the fact still remains that the total population has been increasing much faster than the rural population, and any effort that the Federal Government can make to improve rural conditions that will insure a sufficient rural population, and to provide means for bringing the producer and the consumer closer together, is justifiable, and from this standpoint alone Federal aid for roads can

certainly be considered to be at this time of great national assistance in one of the greatest national problems which we have.

#### BIG RESULT OF FEDERAL ROAD ACT.

The results accruing from the Federal aid road law up to the present time, because of the conditions during the period from which we are just emerging, can not fairly or honestly be reckoned in the number of miles of finished road. The big result, so outstanding as to overshadow every other consideration, which can be primarily credited to the Federal aid road act, is the amount and character of advanced road legislation which has been written into the laws of every one of the 48 States. These laws, in connection with the Federal aid road act, have established on a firm basis, with adequate support funds, highway departments in all of the States which did not have highway departments prior to 1916. In the States which had highway departments prior to that time the legislatures have enlarged and strengthened the authority and increased the support funds of the departments. This legislation has in general provided for more than the building of the Federal aid roads, and in some of the States has included provisions for the building of the roads from the greatest to the least important. In addition to the legislation, great sums of money have been made available through the levying of special or general taxes, and through the authorization of bond issues.

The Federal aid law should not be credited entirely with this changed viewpoint on the part of the public interested, but it can be credited with appealing in a most forceful way to that characteristic of the human race which is perfectly willing to exert itself greatly to secure some reward. Probably without Federal aid the conditions after the war and the changed attitude of the public generally toward public spending on a large scale would have made themselves manifest, but certainly the Federal aid road act can be credited with having turned the attention of the public toward the expenditure of public funds for highway purposes.

It was not possible to go ahead with the actual production of roads on any considerable scale during 1917 and 1918. During the present year a large mileage of roads has been placed under contract, but the production has still been disappointing, due to conditions which are now well understood; but during this period there has been a remarkable development in the fixing of systems through the classification of roads, so that now we have in each State a system of main or State roads more or less definitely fixed, and in many of the States other systems of lesser degrees of importance. Many of these systems have been worked out very carefully and painstakingly, in fact it is doubtful if

the highest administrative and executive officers of the State highway departments have devoted as much of their personal attention to any other single phase of the highway work as they have to the actual classification of roads. For the last three years this has been perhaps the chief and most important work that these men have accomplished, and its importance should not be underestimated.

#### FEDERAL AID TO STATE SYSTEMS.

The proper classification of roads is basic and fundamental, and it has been demonstrated in those States which have carried out this classification in a careful, thorough manner, that people acting through their State legislatures have provided the ways and means for carrying out the program of improvement in accordance with the importance of the roads. Let it here be clearly understood that the people of this country will support a policy of road building which is based on their economic needs. It has been pretty well demonstrated in individual States that the mileage of the primary State roads can not be restricted to too small a percentage of the total. Most of the States have found it necessary to add to their original conceptions of an adequate system a considerable mileage, and where this action has not been initiated by the State highway department itself it has resulted through legislative action. It has been pretty definitely established that a system of primary roads must be sufficiently extensive to give service to all parts of the State. It is hardly safe to fix the percentage without further inquiry, but it seems evident from the result in States which have made a careful study of their economic needs, that in the neighborhood of 5 to 7 per cent of their total mileage will be included in their primary systems. This percentage may change slightly for the Nation as a whole.

Unquestionably at the present time Federal aid should be restricted to the State systems, and since it is true that the State primary systems can in general be divided into roads of first and second importance, it might serve the economic needs of the States to confine Federal aid expenditures to the roads of the first class in the primary system. It is likely that this will be more possible in the older States than in the newer States where it is absolutely necessary to develop a considerable mileage of roads in order to give the people access to all of the different sections of the State. That is, there are some sections in which a smaller mileage of high class roads is necessary to meet traffic demands, and there are other sections in which a longer mileage of cheaper roads will as adequately serve the traffic needs, and which is the only policy that the public will support at the present time.

#### CONNECTING PRIMARY SYSTEM.

The step which seems necessary now is a definite plan of cooperation between the States and the Federal Government, which will insure that the primary systems of each State are connected up with the primary systems of the adjoining States, and that these systems, by agreement between the State and Federal authorities, be held to until they are properly improved.

Up to the present time the Bureau of Public Roads has made its objective the perfecting of the administrative relations with the States. These relations have in general been placed on such a basis that better engineering standards can be developed and enforced, and it is undoubtedly a duty of the Federal bureau to stand behind the States in their efforts to provide roads that will be adequate not only for present traffic but for future traffic. This point is of great significance, particularly in those States where roads are being built from bond issues and where it is doubtful if adequate maintenance funds will be provided for those types of roads which will require high maintenance cost.

It is true that the Federal aid act requires the greatest cooperation between State and Federal authorities in order to make the plan outlined by the law an efficient method of operation, and yet it has as its fundamental basis a plan of action that will have to be used more and more in carrying out large public or private enterprises that are undertaken in this country, and the sooner this fact is recognized and put into operation the better it will be for the industrial life of the Nation.

There is now comprised in the 48 State highway departments and the Federal department a very large proportion of the engineers of this country who have had actual highway experience, and these agencies can, through cooperation, provide the most effective administrative organization that it is possible to devise. The fact that a considerable portion of these administrative officials are in close contact with the public in all the different localities of the Nation, insures the development of the roads which will answer the greatest economic needs.

#### MODIFICATIONS IN FEDERAL LAW.

In the law itself there are certain modifications which undoubtedly should be provided for the extensions of appropriations for carrying out this act. One of these is the \$20,000 per mile limitation, which is not now so much of a handicap but may later become so. There are roads being built where the grades themselves, because of the topography, will cost without

surfacing nearly up to the limitation now imposed by the law. After these road grades are properly settled they should be surfaced where the traffic justifies.

In many of the sparsely settled Western States there are large areas of federally owned lands through which the State systems must be projected, and in many cases the roads through areas of this character are necessary links in trans-State or transcontinental lines. To prevent an undue burden falling upon the States which can ill afford to build such roads, consideration should be given to the extension of the appropriations which are now made for the building of roads in the forest areas. These roads in general are of two classes—those which are necessary for the administration of the forest areas themselves and those which form important links in the State systems. Again, there are roads notably in the Western States, but found also in some other localities, which are of greater importance as links in trans-State or transcontinental lines of travel than they are to the immediate locality.

If the States in which such roads occur follow a program of providing first those roads which meet the

greatest economic needs of their people, some of the through roads will necessarily be delayed for some time, and the advantage of a long line of improved roads on either side may be largely lost because of such unimproved stretches. To take care of cases of this kind consideration should be given to a provision which will allow the bearing of a greater part of the cost from the Federal-aid funds than the 50 per cent now specified. Such procedure would undoubtedly be fair and reasonable, but if adopted it should be carefully restricted and guarded so that the roads which ought to be improved as links in long lines of travel will receive first attention.

These points summarize the most important modifications which it seems now necessary to make in order that the present Federal-aid law, through cooperation between the State highway departments and the Federal Bureau of Public Roads, may meet satisfactorily the National need for improved roads, and insure the completion of roads in the order in which they meet the economic needs of the individual communities and of the whole Nation.

## Making Highways Ornamental and Useful.

JOHN A. HAZELWOOD, Chairman Wisconsin Highway Commission.

OF ALL the constructive work that is done, there is none that counts more in obtaining good results than the planning and preparation that goes before the actual performance. We realize that good roads lie at the basis of social institutions and the associational life of every community. Good and attractive highways can not possibly be obtained unless they are planned.

The period of achievement in the road work is not over, but we are entering upon new phases of the problem, mainly because we are seeing things in this motorized age in a different light. We are in a new era of social development and national growth and the question is not whether we shall continue to expand but how we are to expand. On some things we have spent too much time and wealth and on others we have spent too little. Those things upon which we have wasted too much are easy to criticize because we see the mistakes, but those things upon which we have spent too little may have caused great losses, although they are not especially apparent. Wealth is produced not from the existence of natural resources, but from the conversion of natural resources into some form of human use. The æsthetic phase of road betterment does convert natural resources into forms of human enjoyment and should be encouraged.

### BEAUTY IS WORTH WHILE.

It is not enough to build good roads, it is not enough to maintain good roads, it is vitally important when we build and maintain good roads that we

beautify them. Roads without embellishments, such as trees, shrubs, and flowers, are ugly and prosaic. It is not enough to consider only the financial side of roads; it is our duty to consider as well the joy that man receives traveling upon them. Any progressive and self-respecting community ought not to allow a mercenary spirit to cause it to disregard the work of beautifying highways. Rural forces should make "Scenic betterment" one of their slogans. All over the New England States we find, in connection with trolley lines, comfort stations with trees, shrubs, and flowers about them, cared for at the expense of the railway companies. We find in many of our cities small parks with shrubbery and flower beds about the railroad depots. These companies do these things because they know they are rewarded for so doing. Rest rooms and comfort stations at regular intervals along the roads add greatly to the joy and comfort of traveling.

We have been careless and thoughtless in the past. We have permitted the woodman's ax to destroy the trees we have admired as bits of forest scenery.

### PLANT TREES, SHRUBS, AND FLOWERS.

We should plant trees, shrubbery, and flowers along our highways. What a splendid opportunity we have for getting good results from nut-bearing and fruit-bearing trees systematically planted and cared for along the public highways of this country. The expense of planting trees, shrubbery, and flowers along our roads and caring for them calls for only a small

expenditure of funds. We should realize that each passing year will add to our pleasure if trees and shrubbery are planted and protected. Little do we realize the returns obtained from this class of service which are not considered in Wall Street or listed in Bradstreet.

We all admire a home with trees, shrubbery, flowers, and trailing vines about it. We know the pleasure that is excited in hearts by these adornments. We can not help but feel sorry for those who are obliged to occupy homes where no attention is given to plants, to flowers, and to trees. A little attention to flowers and trees will transform ugly lawns into spots of beauty. We can not look upon a beautiful tree or a cluster of shrubbery without forgetting a frown and getting an inspiration for higher thinking. The shade and the freshness of trees along the roads running out of any village or city are needed now more than ever before. Concrete roads and hard-surfaced roads of all kinds are cold and need some softening effect.

#### BEAUTY AND PROFITS.

Beauty and profits usually do not go hand in hand. However, beauty is oftentimes combined with utility and this is true in road building. One can note at a glance whether a road has had the touch of an artist. A curved road is much better adapted to artistic landscape than a straight one. If to this curved road are added the touches of the tree, the shrub, the flower, we have pleasing associates as we travel along. It does not take a landscape gardener to tell whether thought and attention has been exercised in connection with highway construction.

We are all interested in civic art. We like to put out best foot forward. Civic art means a constant endeavor to secure in our public works the maximum of utility combined with the maximum of beauty. Cities have realized the importance of this and have given large attention to parks, playgrounds, and boulevards. In fact, proper attention to roadsides means a definite increase in the pleasure of traveling and a substantial addition to the value of adjoining property. Cement, macadam, and gravel roads particularly need the protecting shade of trees.

#### BEAUTIFICATION WORK.

We know that many European countries have spent and are spending large sums of money in planting and caring for trees along the highways. Many trees along highways are apple, plum, and cherry, and from these large profits are annually obtained. The southern counties of the United States have given some attention to the matter of beautifying the sides of roads. The counties, particularly of Florida, have expended lots of money in beautifying their highways. Los Angeles County, Calif., spends annually \$7,000 a year for the purpose of

planting and taking care of roses along the highways.

The beautification of one country road in Los Angeles County has recently been completed. The road, which is known as the Sherman Way, extends 28 miles through an agricultural district near the city of Los Angeles. The district was originally embraced in a 47,000-acre ranch, which was taken over by a real-estate company, and about three years ago the work of beautifying the road was undertaken. It was completed last winter and the road formally turned over to the county, which in future will maintain it. The beautification has consisted of the planting of rosebushes and trees along the roadside. The rosebushes are planted at intervals of 7 feet along each side of the road. The different varieties of roses are grouped together. In all, there are approximately 80,000 rosebushes. The total cost of this work was practically \$100,000.

Many other counties in California are annually spending large sums of money in beautifying their highways. These investments are paying well, and the counties that have had this experience in beautifying their roads realize this and intend to continue to expend money on landscape work.

#### NEGLECT OF ROADSIDES.

We have been a little careless in the road game of late. Many road builders have destroyed beauty by permitting the careless cutting out on the side of roads of the blackberry, the hazel brush, the wild rose, and the wild crab and thorn apple. The transformation of many roads by our so-called professional road builders from the rustic, beautiful drive to the barren highway seems almost brutal. In many cases everything has been grubbed out. Bare spots mark the places where beauty went up in smoke and flame. This change from the beautiful to the ugly has not been called for and should not have been permitted.

One distracting thing along the country highway is that of advertising. We see the billboard destroy the beauty of many pretty glens and beautiful curves. The greed of advertisers has destroyed many beauty spots by putting up advertisements of liquor, patent medicines, tobacco, and corsets. This destruction of beauty has been somewhat handled through city ordinances issuing permits or licenses. Women's clubs in our cities have done much in the matter of curbing landscape destruction by billboards. Little has been done in rural districts to restrict such advertising.

It seems that the most effective way of handling the question is the exacting of a tax. I believe we could drive away much of our advertising on billboards that can reach the eye of the traveling public. In order to not be unduly hard on those who have already erected their billboards, half or quarter the

rate might be charged them until they take them down or have them repainted. This is one of the effective ways of handling this manner of destroying the beauty of our highways.

#### NEED OF LANDSCAPE ARTIST.

Every highway commission should employ a landscape artist. Delaware has already taken that step. There should be a landscape artist abroad in the land. Nothing counts like expert advice and direction in the handling of important problems. We can not afford to let this matter of rural planning continue to be worked out under our indifferent amateur policy if we wish to make our roads ornamental as well as useful.

We all enjoy a beautiful road and drive. Nothing is more pleasing to pass over than a road stretching ahead, running by farmhouses, wayside schools, churches, and villages. The automobile has crowded two, three, and even four hours into one hour as compared with the horse-drawn means of transportation. A road seems to have moods and whims. Sometimes it stretches on and on into infinite space; sometimes the eye loses it in some wistful curve; sometimes it loiters in sunny vale.

Some one said, "The important thing to me about a road, as about life, is not that it comes from somewhere and goes somewhere, but that it is livable where it goes." The invitation to explore the unknown road is very alluring. The unknown road as it winds along is a perpetual revelation of beauty. One person rightly says that he greets a new road with almost as much pleasure as a new person and usually parts with it with rather more reluctance. It is curious, indeed, how closely roads are linked with humanity; how warmly companionable they are. A public road talks business all the time. It tells us new things about everything that appears in a panoramic view on the roadside. It tells about the farm homes and the type of farming that is being carried on by the owners. It is one of the most important and interesting of all of man's wonderful institutions.

#### BEAUTIFUL ROADS ARE EDUCATORS.

We never receive our friends in our woodshed and break bread with them in a corner of the kitchen, using our ordinary linen, silverware, and dishes, but we receive them and entertain them in the most comfortable rooms in our home. We dine them in our most pleasant room and we use our best linen, silverware, and dishes. What for? Why, for the very purpose of impressing upon them that we are maintaining good homes. Our visitors are usually our friends. They bless us and make us happy and contented. Therefore, we are justified in spending a great deal of time and money in providing attractive

lawns, beautiful entrances, and pleasant homes. The portals, the gateways, the entrances to our community homes are the highways.

Many of our cities understand the value of having inviting boulevards and streets for guests to enter. Large attention is given to the main entrance to commercial and residential centers. They beautify the streets with park rows, with trees, hedges, shrubbery and flowers so that visitors may feel more welcome. Rural communities should take the same interest in their roads. They should not only build and maintain roads but they should beautify them to give their friends a good impression of their homes.

We find many so-called self-styled "practical men" who do not realize the importance of beautifying country highways. Lloyd-George said that there is nothing more fatal to a people than it should narrow its vision to only material things. We need beautiful streets and highways to stimulate the imagination and exalt the vision of our people. We know that good roads mean good schools, education, and prosperity and that bad roads mean poor schools, ignorance, and poverty. Beautiful roads are silent educators. Each beautiful thing makes a good and lasting impression upon the plastic mind of man, and when we consider that an ugly road makes the opposite impression we should realize our responsibility in the matter of adornment of our highways.

---

#### NEW TEXAS ROAD MATERIAL.

Ten miles of road outside of Rockport, Tex., according to the State highway department, is being surfaced with a material which analyzes more than one-fourth epsom salts. The material is obtained from flats where constant evaporation of gulf water has left silt strongly impregnated with salts, among which the epsom variety predominates.

Highway engineers declare the mixture forms an excellent road surfacing material, as the salts absorb enough moisture from the air to keep the roads damp, free from dust and firm on the dryest days. One trouble, however, is that the road becomes very slippery during wet weather, but this is overcome by adding a small proportion of shell and regulating the the slope of the surface.

---

#### SPOKANE, WASH., ROADS.

Spokane, Wash., plans to build about 32 miles of permanent highways this year under the county program as outlined in the recent \$3,225,000 road bond issue. They will cost about \$425,000, or about \$12,500 a mile. All surveys for these roads have been completed and it is expected that the contracts will be let before the construction season opens.

# Design of Highway Drainage Structures.

CLIFFORD OLDER, Chief Highway Engineer, Illinois.

IN discussing such a question as this, I presume all of us talk from the point of view of our own State, modified by the injection of a little idealism. So I shall talk largely from the point of view of Illinois.

As the result of a number of years of study we have adopted, in Illinois, a standard width for graded or trunk line roads of 30 feet from shoulder to shoulder. Of course, we make exceptions to the rule where we encounter difficulties or extraordinary expense, but the width usually is 30 feet. Our bridge widths are related to this standard graded highway width.

## WIDTH OF THE STRUCTURES.

We define drainage structures with spans of less than 8 feet as culverts; those with spans over 8 feet in length we call bridges. All our culverts are built the full width of the highway, so that the roadway is as wide over the stream as at any other point. The larger structures are not built so wide. That is the general, not the invariable rule. As a large part of the land in our State is prairie land, there are districts where one can ride mile after mile and pass only an occasional drainage structure over 8 feet in span. On such roads we frequently depart from the general rule and build all the structures of less span than 30 feet to the full width of the roadway.

Of course, we should like to have a traveled way without restrictions of any kind, but we have not been able to bring ourselves to that point yet. In the matter of long-span bridges, we think in dollars and cents, and we cannot consider the idea of doubling our bridge expense, which is already heavy, even to secure an unrestricted roadway.

Speaking, incidentally, of prices, it has been interesting to me to note that while road work has about doubled in cost, bridge work costs three times as much as in prewar days. For a period of 5 years preceding the war structural steel averaged a little less than 3 cents a pound. At present, we are paying more than 9 cents per pound, or three times as much. The average cost of reinforced concrete bridges and culverts during a 4-year period prior to the war, was \$12.50 per cubic yard, including the steel; now they cost from \$20 to \$30 per cubic yard, and the steel is paid for as an extra. In our State more than 90 per cent of our structures are of this type. We are giving considerable thought to the problem of reducing the cost by revising the standard designs of a number of years ago, eliminating excess material wherever possible.



CLIFFORD OLDER.

On the long-span steel bridges we have been following the practice of substituting for the customary concrete floor a floor of creosoted block on creosoted plank as a supporting element, and we find that we effect a saving in the weight of structural steel which will more than pay the extra cost of the creosoted blocks and plank as compared with concrete.

## ONE-COURSE CONCRETE FLOORS.

We have changed our policy in regard to concrete floors. Formerly I was firmly convinced of the need of building the concrete floor of a steel bridge in two courses, with a distinct plan of cleavage between the upper or wearing course and the lower course, which I considered as the supporting element, so that we could entirely wear out the wearing element without affecting the strength of the supporting element.

However, after long experience with concrete roads (some of them built 8 or 10 or 14 years ago) we have now come to the conclusion that the wear of a well-built concrete wearing surface under auto traffic may be practically disregarded. So we have changed our practice. We are now building our floors in one course, adding  $1\frac{1}{2}$  or 2 inches to the thickness of the former supporting slabs and abandoning the independent

wearing surface entirely. We find that the change is in the interest of economy, because it was necessary formerly to build the wearing course at least 4 inches thick, or if thinner to reinforce it to prevent cracking.

The matter of bridge loading, and pavement loading as well, has been greatly simplified in Illinois since the last session of the Legislature. We were fortunate enough to be able to pass a law regulating the weight of vehicles which may use our rural highways, and, indeed, our city streets also, with the provision, however, that the city governments may increase the loading specified by the law by as much as 50 per cent, if the council so desires.

#### LIMIT ON THE LOAD.

We now limit the loads to 16,000 pounds per axle. We thought at first we should like to have a wheel-load limitation, but we found that such a limitation would get us into difficulties with the truck manufacturers, and as we felt that very few vehicles would be symmetrically loaded, we concluded to consent to the limitation of axle rather than wheel load. The gross load of the vehicle is not specified. It may be any amount, providing no axle load exceeds 16,000 pounds. Under the new law, if a motor truck could be designed to distribute its load equally to each of its four wheels, the gross load of the vehicle might be 16 tons. But in many cases the gross load of the vehicle is not the critical factor; the wheels are far enough apart to act practically independent of each other on a pavement surface.

Before this law was passed any load a man might choose could be carried over a pavement or bridge. A brick house might be moved down the road, as they actually did in one case, in absolute disregard of the strength of the road or bridge. Such objects may still be moved over the highways with special permission of the road authorities having jurisdiction. Of course that means, in the case of practically all paved roads, the division of highways, or department of public works and buildings.

Our practice in designing concrete bridges in the past has been to provide for the equivalent of a 24-ton steam traction engine or motor truck. In proportioning the bridges we have allowed a compressive stress of 1,000 pounds per square inch. We have built bridges designed in accordance with these assumptions, and 12 years' experience indicates that they have been safe. Our practice in this respect has been criticised, but we have never had a failure of one of these bridges. However, for such structures, in view of the stress we allow, we shall probably adhere to the old loading.

As an alternate to the 24-ton concentrated load, we provide for a distributed load of 125 pounds per square foot, if the distributed load produces a greater stress than the concentrated load, which it does on spans of more than 28 feet, I believe.

We feel that our bridges are seldom, if ever, subjected to these maximum loads. When we adopted the 24-ton load limit we had steam plow engines that weighed that much. But those have gone out of fashion, as have nearly all the steam tractors, and they have been supplanted by gas or oil tractors which weigh only 10 or 12 tons. The maximum distributed load is also rarely, if ever, attained. So far as I know the nearest approach to the equivalent of such a load, which our bridges have ever been called upon to carry has been a heavy tractor and a train of Troy trucks. But such a train is rarely over 50 feet in length, and even such a load does not produce a stress in a 150-foot bridge which approaches the stress assumed in the design.

Furthermore, suppose that 1,000 pounds per square inch does equal one-half the ultimate strength of the concrete, experiments with loads indicate that we actually do not exceed one-half of the ultimate strength. It would require several thousand, or several hundred thousand repetitions of such a load in order to cause the structure to fail under compression; and the ordinary highway bridge will have been washed out or destroyed by tornado or fire before the maximum load will ever be sustained 1,000 or 5,000 times.

The use of the high stress enables us to design economical bridges that span from 60 to 65 feet.

#### ORNAMENTATION OF STRUCTURES.

Ornamentation is a subject upon which it seems that every one has his own ideas. Early in the game we found great difficulty in inducing the people to pay for ornamentation, but, of course, when we furnish our own funds we can do as we like. For some years we have thought we were designing fairly sightly bridges; at any rate we had concluded that our bridges were not unsightly, until a convention of architects met in Springfield and told us we knew nothing about it, that we were designing hideous structures, eyesores, and all that sort of thing. But as architects and artists differ as much as engineers among themselves, I believe we have as much right to our opinion as they have to theirs.

Indeed, I believe that the engineer who gives some study to the appearance of his structure is more likely to produce a bridge which will please the public than the architect, who is apt to use too much gingerbread. We have some architecturally designed bridges in Illinois, and to me they are decidedly not pleasing structures.

In our bridge designs we attempt no useless ornamentation. We believe in the beauty of proportion and simple lines, revealing the structural features. Personally, I do not believe in making a girder bridge look like an arch by putting false curved walls along the side. Anybody who has ever seen an arch can tell it is not an arched bridge. When we design a girder

bridge we intend it shall look like a girder bridge. If it is an arch, we do not attempt to deceive the public into the belief that it is a girder. Of course, everyone has a right to his opinion in such matters.

There is one thing that we have found, and that is that we have been mistaken in the amount of camber we have been putting into steel structures. We have always decided how much to use by means of side-view drawings, and we have been led, thereby, to use too much. We find that the camber which seems to be right when viewed from the side appears to be excessive when one looks down the roadway and sees the hump in the arch. And as 97 out of 100 people see the bridge between the rails rather than from the side, we have gradually reduced the camber, until now it is something like an average of 4 inches to 100 feet for a series of spans.

---

#### DISCUSSION OF MR. OLDER'S PAPER.

WILLIAM F. COCKE, assistant commissioner, Virginia: The subject Mr. Older has talked to us upon will cover, I think, these four headings, which I would group in their relative importance as follows: The first and most important feature of a drainage structure is: Strength, capacity to carry the loads regardless of its adequacy of size. If it is not strong enough, though sufficiently large, it will be dangerous. The next most important feature is: Adequacy, sufficient area to carry away the water that will go through it at high-flood time. Third. Durability; we want to build something that will be durable. Fourth. Appearance.

It strikes me that Mr. Older is leaving two very important factors out of his calculations when he figures on a design that will give 1,000 pounds to the square-inch compression. Those factors are inferior material and inefficient inspection. I do not question Mr. Older's theory at all. But I do know that in a great many sections of the country we have to put up with inferior materials, and in the present condition of the market for engineers and inspectors we have to put up with unknown quantities in the way of inspectors. Taking those two points into consideration, I personally would be very dubious about attempting for the State a work following a design with the stress he recommends.

I believe in a great many instances a designer labors either under misinformation or inadequate data in regard to conditions under which the construction will have to be carried on. I know I have been just as guilty along that line as any other field engineer, and I don't think that time or expense should cut any figure in securing the necessary data on which a design for a structure is to be based. I have in mind an instance which occurred within my experience in the last two years where approximately \$300 additional expendi-

ture in collecting the preliminary data for a \$200,000 structure would have saved a good deal of embarrassment, and possibly some unnecessary expense, in connection with the construction as it was actually carried out.

I think that soundings are not always adequate or sufficient in testing the foundations for large structures. In a great many instances, where the structure is on a solid-rock bottom, it should be tested with a well drill or some other means to find its thickness. Samples of the supposedly solid rock should also be secured.

Another fact to be considered always is the drainage area. I do not believe we can tie ourselves to the drainage areas as they appear from an insufficient examination. The examination should be very thorough, and in addition to drainage areas, I think it is very important to take into consideration records of extremely high water from whatever cause (unless caused by artificial reasons, as a dam which has ceased to exist), and the design should be made accordingly.

In regard to width, I heartily agree with Mr. Older that 20 feet should be the minimum width for our modern structures. They should be certainly that width to allow two vehicles to pass safely. It is rather a short-sighted policy to consider a 16-foot bridge, especially of the high-truss type.

There is an urgent need, and has been for several years past, for some national or cooperative State legislation to decide on a definite limitation of the wheel or axle load to come upon our bridges. We design a pavement to carry a certain load, and if it becomes inadequate within 10 or 12 years or 15 years, we have nothing more to dread than a destruction of pavement and the pavement is of itself more or less temporary in nature. But when a concrete bridge structure is erected it should be, if we can make it so, sufficient certainly for our generation if not for all time. Therefore, if we are to design a highway bridge structure intelligently we must do it with some definite loading in view, or else our work will be of a very temporary nature and will be found inadequate by the next generation if not by our own.

---

#### NEW YORK'S 1920 PROGRAM.

State Highway Commissioner Green, of New York, has announced that plans have been made for the construction of 172 roads this year. They will have an aggregate mileage of 725.5, of which 527.26 will be constructed of reinforced concrete, in keeping with the policy to build only permanent roads, which will last from 25 to 50 years under the heaviest traffic and at a lower maintenance cost than lower types of roads. It is expected that all contracts for these roads will be let by the end of April in order to make it possible to complete the roads during the working season.

# The Marking, Signing and Making Safe of a State Highway System.

LEVI H. NEILSEN, Deputy State Highway Commissioner of Michigan.

## MAPS AVAILABLE TO PUBLIC.

UNDER the legislation providing that the State trunk-line system previously established by law should be "improved, constructed, and maintained under the direction, supervision, and control of the State highway commissioner," he was also instructed to "cause all State trunk-line routes to be distinctly marked by signs and guideposts of a uniform design as may be deemed necessary for the public convenience and necessity," and "to cause to be published a map of the State of Michigan showing thereon the State and county road system." Provision was also made for numbering the routes and showing the corresponding numbers on the roads shown on the maps.

Following out the provisions of this legislation several designs were considered, with the result that a standard design was agreed upon consisting of a diamond 15 inches in length and 13½ inches wide. Across the middle will appear the words "State Trunk Line" with a block "M" above and the numbers of the route shown below. For the markers to be used on telephone and telegraph poles a black letter on a white background will be used. This will also apply to markers placed on buildings and suitable natural objects along the roadside.

For this preliminary marking stencils and county maps showing the roads to be numbered in each county have been prepared and instructions to the county authorities made ready to send out.

These markers will be placed on telegraph and telephone poles when they are available, on both sides of each intersecting cross-roads with an occasional one in between. Three to six hundred feet before a turn in the road is reached the white band will be widened and an "R" or "L," as the case may be, shown below the standard marker. Where a pole is not available and no buildings or natural object will answer the purpose cedar posts will be set up and the markers placed on them.

Standard railroad-crossing signs will be shown about 600 feet from all grade crossings. Dangerous curves will also be marked.

Although it is not the intention to maintain that portion of the routes lying within incorporated cities and villages previously paved, it is very necessary that it be plainly marked through every village and city. It is our intention to place direction signs at the intersection of the routes with improved roads showing distances to the nearest town.

For the present no marking of the county road system is planned, although it is expected that a standard design for marking them will be decided upon within another year. The marking so far referred to is primarily intended for the guidance and information of the traveling public. In order to make this information most valuable, the map referred to must be provided and made available to the public. Because of the shape of the State, it was thought advisable to issue two separate folders, one showing the routes in the Upper Peninsula and the other those in the Lower Peninsula. This map is now being published and will be available for distribution by the time it will be possible to do the marking, which will be early next year.

In addition to this marking it is proposed to place mile markers on all the routes. Locations for these will be determined by automobile speedometer readings. These mile markers will consist of black diamond-shaped boards with a white molding border and the standard lettering in white. These will be set on angle-iron posts. The posts will be numbered from the south to the north and from the east to the west.

At the same time that the location of the posts is determined a variety of information can be gathered and compiled for future use.

## DISCUSSION OF MR. NEILSEN'S PAPER.

FRANK T. SHEETS, engineer of design, Illinois: It might be interesting to the members of this association to know the system which has been adopted by the State of Illinois for marking the State bond-issue routes as constructed. We have adopted a concrete sign. The head of the post is 4 inches thick, 2 inches wide, and about 20 inches high. It is made of concrete, using a white cement. The outline of the State is grooved into the post, and the outline then is painted black. On the face of the post appears the number at the top, "24," indicating the number of the State bond-issue route as fixed by law. The red figure "142" indicates the location of this marker on the system, and this same number will appear on the State map, which we will ultimately complete, which will show the location of point 142 on the map. This 142 tells a dual story. It serves to locate the point in the field with reference to the map for the con-

venience of the tourists, and also indicates the approximate mileage from the eastern and northern terminals of the route. At the bottom appears the letter "L" or "R," which we all know is the conventional sign for turn to the right or left.

These posts have a total height of 8 feet, are embedded in the shoulder of the road adjacent to where the ditch breaks off, to the extent of 3 feet, so that the post stands 5 feet above the ground, just where the vision of the driver will naturally catch it, also where a headlight will pick it up at night. This we find is meeting with universal approval among the motorists of Illinois. I think we can not too fully emphasize the importance of properly marking the highway system when we build it.

We have been including these posts as one of the items in our contracts, but we think we are paying too much for them. The contractors have been bidding something like \$20 a piece for them, so we have almost come to the conclusion that the proper thing to do is to let the contracts for the road and the markers separately.

#### WISCONSIN MARKER SYSTEM.

J. T. DONAGHEY, maintenance engineer, Wisconsin: It might be of interest to say a word about the Wisconsin marker. We have had the system marker now for two seasons and it has proved very satisfactory. Our main truck line system is marked, beginning with 10, and going as high as necessary. We number from east to west and from the south to the north. The plan was originally designed for the benefit of our construction men. But now we are going to give the public some benefit of the mile numbers. Our mileposts are flat, made of 3 by 6, and are painted with the number of the trunk highway. The first milepost has "1" on the south side and "2" on the north side of the post. The next one has "2" on the south side and "3" on the north. So you you know you are in mile 2 or mile 3, as the case may be. Everything is on that basis.

This year we are getting out a new map and are preparing an index that will tell the traveler exactly where he is at any moment. Turning to trunk highway No. 17, it would have an index that would give the mileage of every town on that highway. So he can tell by the number of the milepost exactly how far it is to any point he wants to go.

We have adopted and are using a very cheap method of marking the system. The marks are the same as Mr. Neilsen has described. We place them on the telephone poles at convenient places. We aim always to have a mark in sight on all trunk highways. At any point looking ahead you should be able to see a mark on a telephone post or posted on a culvert wall. The head walls of all culverts and bridges are painted white and the mark which we use is a triangle containing the

trunk highway number. That mark is placed on the right head wall of the culvert. On the left is the number of the culvert.

#### WOOD USED ALMOST ENTIRELY.

We use wood entirely except for danger signs, which are enameled steel and not satisfactory. The wood signs are satisfactory. If we had it to do over again we would use wood for all purposes. They are set on cedar posts, which we can buy very cheap in Wisconsin. We find that we have to change quite a few posts, mileposts especially. We make a great many relocations. Sometimes we get away entirely from an old road, especially on what we call permanent roads. So we have to move a great many mileposts until the system is completed, and we believe wood is much cheaper than anything else; and until we finally develop the system to the point where we know we are going to leave it we don't believe we will place concrete marks and signposts.

The mile marks to be placed on the signs were determined by speedometer measurements. After the system was selected, as provided by the legislature, we made what we called a conditional survey of every mile on the system. We have in the office a chart from each county showing what was found at that time, the type and condition of the system. At the time we made those surveys we located the milepost and the speedometers were calibrated for correctness. We ran out a mile of steel tape and made our speedometers correspond with the actual measurements within a few feet. Many times we had to change the tires to get the speedometers to read correctly. We think it is very accurate as far as distance is concerned.

At the same time we located all signs. We had a black sign copy for the boys to use. A stake was set 2 feet back of the point where the engineers determined the mileposts should be placed. It was placed where automobile lights could reach it at night, not too far toward the outer edge of the right of way, and still, out of the way. The stake we placed carried the number of the trunk highway, and the number of the milepost. If it was a direction sign the stake carried the letter "D," the number of the sign, and the number of the trunk highway. The sign was painted from the information supplied on the sign copy, and the sign was erected by the county.

In marking through cities and villages we insisted upon having a mile mark on each side of all street intersections. That is, we have two mile marks as near as possible to the street intersections throughout the cities and villages. That is very essential. People get lost in the cities and villages easier than any other place. So we have adopted that plan of having two marks in every block. When you get near the intersection you know you are all right. The "R" or "L" shows you where to turn.

### INTERSTATE COOPERATION.

All trails passing through our State must be marked to correspond to our marking system. Persons interested in marking such trails must follow our marking instead of theirs. So far, the marking of trails has done us more harm than good.

An excellent beginning has been made along the line of interstate cooperation in marking the through roads. I believe Minnesota has carried our No. 12 through Minnesota. Michigan has carried our No. 15 through the peninsula. Illinois is thinking of carrying our No. 10. I believe adjoining States that are intending to number their highways should take the matter up with the other States. Our highway No. 12 should start at Chicago. We ought to start our numbering at Chicago and pick up the distance at the border. Let Minnesota take up the distance at her border. The traveler would then know where he was all the way. If we can cooperate in that way we can work out a marking system that will benefit all the States.

Just another word in regard to detours. We mark detours plainly, with large white boards, showing the trunk highway number and an arrow pointing the direction of the detour at each end, and many times along the detour to show the traveler where to go. We also have paper detour signs which we nail on the telephone poles instead of painting on. In connection with that, we have the patrolman maintain the detour on his regular section.

### EXPERIENCE IN MINNESOTA.

J. H. MULLEN, chief engineer, Minnesota: We have had experience with painting trail signs, which at first was very unsatisfactory. Professional trail painters came into the State and would go to various villages and get them to contribute money, anywhere from \$15 to \$20, to paint blue, green, or red trails. The location of the trails depended on where the professional painter got the most contributions, and had no relation to the best road to travel, although they tried to follow, I suppose, the main lines of traffic.

The condition promised to become so bad that we had an act passed by the legislature making it a misdemeanor to paint signs on the public highway, except when approved by the highway department. So, now if it is desired to paint a trail through our State, permit has to be given by the highway department. There must be an incorporation of the organization that is going to paint the trail. They must give us a record of their organization, where the trail is to be painted, a complete map of it, and a drawing of their design. Then they are protected in that design.

For instance, take the Burlington way. They have an orange and white marking which runs all the way through the State and happens to be a good marking.

They paint every telephone pole so that you see one continuous line of orange and white along that road. They filed that mark and no one else will be permitted to mark orange and white markings of the same form on a highway. They are obligated to keep that up, and it is a misdemeanor for any one to deface those signs or reroute the road.

We had some trouble at first. Perhaps a man with a garage two squares off the traffic would paint a sign to point his way. That sent the stranger out of his way and with the large body of tourist traffic in Minnesota it meant quite a lot.

### RIGHT-OF-WAY MARKS.

W. S. KELLER, state highway engineer, Alabama. This might be of interest to some of you, especially the southern engineers who have been troubled as we have with encroachments upon the right of way. We established right-of-way marks. We get 50 feet right of way, generally, for our roads and at the P. C. and P. T. and on long tangents, at intermediate points, erect simple little concrete right-of-way marks, placing them right on the border of the right of way. So far the contractors, generally, have bid from \$2 to \$2.10 apiece. The mark is about 5 feet in length, 8 by 8 inches at the bottom, and 6 by 6 at the top, approximately, with the letters "R. W." sunken into the upper part. It stands out of the ground about 2 feet. We believe that will preserve our right of way and future trouble will be avoided by it. We have had a great deal of trouble in the South for years past. Farmers have what we call snake fences. When they build the fence the center of it is on the line; but when they improve with a wire fence, they build the new fence before they tear down the rail fence and they are very particular to put the wire fence on the outside. So they are constantly taking the right of way. We believe this a very easy way to retain the right of way that we secure.

### INTERSTATE NUMBERING SYSTEM.

M. W. TORKELOSON, bridge engineer, Wisconsin: I have often thought that we should have an interstate marking system with each State adopting the interstate number for through roads passing through the State. We would have a system then that would work nationally and locally. I think the members of this organization should get together and bring that about. A man could travel from New York to San Francisco following one number all the way, and as the trail passes through the State that number (say 21) would be the State's number for the road also.

If anything like this were attempted, I believe the interstate numbering system should carry for each State a color which could not be used in any other State, so that the traveller would know, by the change in the color of the markers, when he arrived at a State line.

# Maps of State Highway Systems for the Use of the Public.

M. W. WATSON, State Highway Engineer of Kansas.

A MAP to be of real value must be prepared along definite lines to meet the needs of its user. Maps of State highway systems may be classified into several classes, but the two most common divisions are those for use of nontechnical persons and those for the use of engineers. The map that will prove the most beneficial to the greatest number of people is undoubtedly in the first of these classes.

To be of service to the general public a map must not be so designed as to confuse the ordinary user at first glance. Contours or other common engineering symbols are as Greek to the uninitiated. The most outstanding feature of these maps should be the main traveled through routes or State roads. Cities or villages must be shown to make the map of service, but they should not be so conspicuous as to make it appear that each place is the center of the universe, as is sometimes done on advertising maps.

Railroads should be shown, but so drawn and designated as to be more of a background than one of the primary features of the map.

Waterways are a necessity to make a map complete and any unusual feature, such as a ford or ferry, should be indicated. In mountainous country and in lake regions these topographic features are of considerable value to the traveler as a matter of location, and should be shown.

It is possible in some States to show on a State map all the public highways open for travel, but such an undertaking in one of our Central Western States where every section line is a road, with a few in between for good measure, would produce a map that is of no real value to the public, being similar in character to a Chinese puzzle.

It seems rather general practice to show the State or primary roads in heavy red lines, with the secondary roads shown by narrow red or black lines, and this method is especially desirable for contrast if the other features are in black, blue, or green.

## ADVANCE IN ROAD MAPPING NEEDED.

Observation of the maps of the different States convinces me that no great advancement has been made in State road mapping to date. Some are in the blue-print state, while others are elaborately engraved. The scales and general design of the maps are as different as the number of States, so that a weary traveler crossing the State line, if guided in his path by published State maps, would be obliged to rest for a while in some shady spot to familiarize himself with the details. This may be an advantage in some cases,



M. W. WATSON.

but it most certainly would be a disadvantage if one is trying to make a certain place in a short time.

One fact, however, which stands out, is that practically all of the States have laid out a system of highways and are working toward their completion, and the great majority connect with each other at State lines so that with the completion of these State systems of highways a national system will be secured, and it will be located to serve the best interests of the States and their people much better, we believe, than would be the case were the system laid out by a national commission unfamiliar with the conditions in each locality.

The maps of the United States Geological Survey are available for detailed information where they have been completed, but a number of States are not so fortunate as to have these maps for the entire State. Coast and Geodetic maps are also of service, especially in States bordering on the lakes or on the seacoast.

## PROGRESS AND SPECIAL MAPS.

For the purpose of showing graphically the progress in constructing State road systems, it is usually advisable to have a progress map so drawn as to indicate the roads under construction, roads partially completed, and roads completed on the State system.

This map should first be drawn showing the State roads with a double line, so that as the work progresses these lines can be filled in, either by different colors or with a progressive system of symbols.

A number of special maps are of use in the work of a highway department. For the purpose of explaining State bond issue elections to the people, skeleton maps showing straight-line connections between principal points are adequate when combined with maps showing graphically the area, population, and valuation affected.

#### FRENCH ROAD MAPS.

The French maps, which were highly praised by service men, are a very complete system of highway maps with every detail shown. The country is divided into sections so as to permit of a larger scale than would be possible if the entire country were drawn in one map, and by referring to a key map on the back of each section they can be very easily combined. A feature of special value to the traveler which is shown on the French map, but which we have not found on any of our American highway maps, is the showing by symbols of all ascents and descents, special reference being given to dangerous descents.

A uniformity of maps should be worked out so that some standard scale and design would prevail throughout the country. It might be advisable that some of the governmental mapping departments handle the preparation and completion of the State road maps throughout the Union so as to have uniformity. The writer suggests that a committee of this organization

be appointed to formulate a definite plan for uniform maps and to report at the next session.

#### DISCUSSION OF MR. WATSON'S PAPER.

THOS. H. MACDONALD, Chief of Bureau of Public Roads: Along the lines of this paper, I would like to say that all the map-making agencies of the Federal Government were recently called into conference by the Secretary of War and the Chief of Engineers of the Army, and certain general policies were formulated to correlate the work of the several agencies and hasten the completion of the Geological Survey sheets.

Their recommendations looking to the completion of these sheets are now before the President. The principles upon which the report is based are, first, that the Coast and Geodetic Survey shall be held responsible for the primary control lines; second, the Geological Survey shall complete the topographical sheets in accordance with their present standards; third, that all other map-making agencies of the Government shall do their work in such a way that the information required to fill in the standard topographical sheets of the Geological Survey will be secured and will conform to the controls established.

The Bureau of Public Roads has up with the Geological Survey now the proposition of getting up standard road maps on the basis of the maps of the Geological Survey, particularly for those States that now have no maps. We hope to carry that forward so that at least we shall have working maps on which to lay out and classify the roads in an orderly manner, and trust that they will give a national aspect to the proposition of road classification.

## The Alignment, Grade, Width, and Thickness in Design of Road Surfaces.

CHAS. M. UPHAM, Chief Engineer, Delaware State Highway Department.

**I**N THE consideration of practices influencing the design of modern road surfaces, with especial reference to alignment, grade, width, and thickness, this paper will deal with generalities, and will not consider specific cases, for it is evident that it would be impossible to recommend any definite method or practice, within narrow limitations, at least, that would satisfy all conditions, as they vary throughout the entire country.

When the problem of the design of highways is taken into consideration, there are several rules that can be followed and accepted as the best practice. These rules are the result of years of experiment and trial and if followed will assure ideal results and conditions, but in every locality there will be varying conditions and local influences which will make it

impossible to follow consistently these fundamental rules of road design.

Almost the first step in the design of a highway is the study of its location, keeping in mind the purpose which the particular highway is to serve. If the highway is constructed as a scenic road, then the problem is well defined, but if the highway is to serve as a lane for commercial or industrial traffic, the problem becomes more complicated and careful study is necessary in considering the question of how local traffic can best be served without lengthening the distance and introducing curvature. At the same time the question of grade must be considered in connection with the alignment. The ruling and intermediate grades kept within an economic per cent, the total cost of grading should also be considered.

The location of a road resolves itself into a problem of economic compromise, depending on the solution of these factors.

#### THE GENERAL PROBLEM OF DESIGN.

There are few localities where ideal alignment and grades can be secured, and though, in most places local conditions and limited topography make it impossible to attempt this ideal alignment, still the inclination to lean towards the ideal alignment should always exist, though it be impossible to attain completely.

There are more variables affecting the problem of width of roadway than in the choice of alignment and grade. The width of highways should be dependent upon the alignment and grade, as well as upon the amount and character of traffic and the character of the roadside.

In considering the thickness of the pavement, there are several features that must be taken into consideration before a final decision can be made. With unlimited funds it would be a simple problem to select a thickness of pavement that would carry all traffic, but the problem is to design the economic thickness—a pavement that will carry the load without any surplus thickness beyond a reasonable factor of safety. Of course, the thickness of a given type of pavement is dependent upon the character, number, and weight of the vehicles that it must carry, as well as the character of the soil in the subgrade, and the possibility of completely and quickly draining it.

In order to keep the consideration of the above subject general, and in order to form a nucleus about which recommendations and practice could be discussed, I wrote to several State highway departments, located in different sections of the country, and asked their practice in the design of roads with reference to line, grade, and thickness. The replies show that on alignment and grade, most of the States were traveling in the same general direction, some approaching nearer than others to the ideal condition. When the question of widths was taken into consideration, it was noticed that in those States, in which were located the largest number of cities, and where traffic had become excessive and the demands for more room had been felt, wide pavements were being constructed.

A uniform thickness of pavements seems to have been followed by all the States, with the exception of those in which were located cantonments. In these particular cases, a greater thickness of pavement has been adopted.

#### ALIGNMENT.

In giving consideration to alignment roads may be divided into two classes, roads located within parks, and intended as scenic roads and used mainly by sightseers and tourists, and roads that can be con-

sidered as commercial or industrial roads, which would be located within and between business centers, towns, and cities.

In the alignment of the park or scenic roads, it is not essential to have long tangents nor direct routes; the only essential requirements of these roads are that they shall furnish lanes of travel for pleasure riders, and shall be properly designed and constructed from the standpoint of safety and beauty. These roads need not be laid off in direct routes, because speed or time is not generally an element to the users of these highways.

The controlling points of the scenic road are beautiful views, magnificent trees, costly residences, and in fact, any detail that may serve the purpose of making the road more beautiful. With the controlling points fixed, the only other consideration is that of safety and the expense of construction.

There seems to be a practice in practically all the States, that, from the standpoint of safety, the alignment of the scenic roads should be such that the radius of all curves should not be less than 300 feet, though in many instances it is common practice to use radii of 200 feet or less.

The commercial road may be described as that road which will most economically serve the commercial or industrial requirements or, defined in another way, may be called the direct route.

In considering the alignment of commercial roads, or direct routes, it must always be remembered that a straight line is the shortest distance between two points, and from a commercial standpoint the shortest way is not only the most direct, but with other things equal, is the most economical; therefore, it seems to be practically conceded that ideally aligned commercial roads are those that are laid in absolutely straight lines.

Where there are costly influences entering the problem that make it impossible or impracticable to follow the straight line, then the alignment should approach the straight line, and become a compromise of line, grade, and cost of construction.

The straight-line method does not require that only two distinct points should be given ultimate consideration, but each and every community and business district lying between these points should be given due regard, and the line should run in the most direct line possible connecting these intermediate controlling points, provided the line will form a direct route.

More stress has been laid upon the alignment of roads during the past two or three years than ever before. It simply shows that highways are passing through the same stage that the railroads passed through when, after exhaustive studies from an economic standpoint, they spent considerable money for the straightening of their lines. The problem of

the highway is practically identical with that of the railroad. Much study should be given to final location, for, after all, the location of a road is the only permanent detail; therefore, this should approach the ideal as closely as possible.

In the construction of hard surfaced roads, the alignment is well defined, and a very small change in direction or a slight angle can be plainly seen. If breaks in the line are necessary they should be located on the tops of hills or summits in the grade.

If necessary to use a curve, then the flatter the curve, the safer the road, and this would not jeopardize the beauty or purpose of the road in any way. When a curve sharper than  $4^\circ$ , or of 1,433 feet radius, is used, the roadway should be elevated on the outer side and widened on the inner side. This will overcome the tendency of the traffic to skid and make driving both safer and more pleasant.

#### FACTORS TO BE CONSIDERED.

A very important feature in deciding the alignment of roads, is the consideration of the through traffic. The ideal road is one that will serve through traffic by direct routes and also make it possible that this traffic need not be delayed on account of congested districts. In other words, the best alignment for a through-traffic road, is a straight line so located as to pass near, but not pass directly through these congested districts. With such a location the through traffic is not subjected to interference or delay which is always present in the main thoroughfares of towns and villages, nor on the other hand is the town or congested district subjected to the hazard of the through traffic. By such a location the congested districts have all the benefits of a modern highway, but are not subjected to its disadvantages. Therefore, when considering alignment, this is a very important factor to keep in mind.

Under alignment, there may also be mentioned the subject of the width of right of way. This we find in nearly every State has been neglected or it has given considerable trouble, when road developments have been carried on in a modern way. Until recently only in a few States were rights of way obtained wider than 40 feet, or was there any effort made for direct routes or straight lines.

With the roadway sufficiently wide to take the amount of traffic and to provide such space as is generally necessary for shoulders and drainage, a minimum right of way of 60 feet should be obtained in districts outside of cities and towns, especially if the country is at all rolling.

When the smaller towns are approached or entered, a right of way of sufficient width to allow for the widening of the roadway to carry the additional traffic should be obtained, as well as sufficient width to carry into effect any beautification scheme, such as

grass plots, flower gardens, and tree planting that may be developed at any time in the future.

In the case of cities, it is advisable in the construction of any road to secure, as soon as possible, sufficient width of right of way to provide for future development, such as might include wide sidewalks, grass plots, areas for tree planting, besides sufficient roadway to take care of the ultimate traffic.

It may possibly be said that through many villages and small cities it would not be practical to secure such width of right of way as recommended, especially after developments in property have been made. This might be true if it were necessary to bring around this condition immediately, but this could be provided for ultimately by establishing new building lines or property lines, making it compulsory that all future development and rebuilding should be a certain distance from the road. In this way a wider right of way would finally result, without the expense of an immediate change.

#### GRADES.

It may be said that a highway, as a factor in transportation, is no more economic or efficient than its ruling grade. Grades and alignment seem to be so closely related, that many times one is dependent on the other, or one is bettered at the expense of the other. In any case the ideal conditions should always be kept in mind, and any compromise should conform as closely as possible to the ideal result.

The same general division can be made with regard to the choice of grade as to line, namely, scenic roads and commercial roads. On the scenic roads safety and beauty seem to be the controlling factors, while on commercial roads the problem is an economic one, and the requirement is that the road be usable at an economic minimum of cost or effort.

In designing the grades for highways there seems to be a general tendency for the States to make an effort to limit the maximum or ruling grade to 6 per cent, with the possible exception of short stretches, which seem to be allowed in most States. This 6 per cent grade was established in the days of horse-drawn vehicles, and while it has served for that purpose it has not been definitely established that it is the most economic grade for motor vehicles. A maximum or ruling grade for motor vehicles is the steepest grade that can be negotiated with minimum of power. This problem is now being studied, but it can only be determined after careful study and experiment and close cooperation with the motor industry.

In most States it is impracticable and almost impossible to hold to a grade as low as 6 per cent, and in these cases, if a grade considerably in excess of 6 per cent seems necessary, a study of relocation should be thoroughly made with an end in view of reducing the grade. It is economic to increase the length of line if a reduction of grade will result.

At the beginning and end of all grades, vertical curves should be used in order that the grades shall preserve a continuity and can be approached gradually, as well as provide a long line of vision. There is one definite conclusion, however, that we can draw relative to grade—the power required to surmount the grade increases proportionately to the per cent of grade. With this law established, we can see that the level grade would be the ideal grade from an economic standpoint. With this definite law, the problem of grade is somewhat simplified and can be determined. In many cases more power is absorbed in overcoming the surface resistance than in overcoming the grade.

It was often thought that before a grade or hill was improved it was the grade that was causing the resistance, when as a matter of fact the road surface probably caused many times more resistance than the grade. With an unimproved surface the grade resistance is a small percentage of the whole resistance; with an improved road the grade resistance forms a much larger percentage of the whole, showing the necessity and economy of reducing grades, if we wish to retain the advantage when hard surfaces are constructed.

After establishing the level grade as the ideal economic grade, all efforts should be made to approach this grade in the design, and any compromise with line or expense of construction should be made with the ideal grade in mind.

#### WIDTHS.

While the requirements of width of pavement can be divided into demands for scenic widths and commercial-road widths, the demands and requirements are so closely associated that only commercial roads need be considered.

While the width of pavement can be said to depend almost wholly upon the character and amount of traffic, the problem still remains far from being solved on account of its being affected by the variable known as the personal equation, a variable to which it is impossible to assign exact values.

The worst condition exists when wide trucks are placed side by side. The average width of the wide truck is 8 feet; two trucks, therefore, would require, theoretically, the entire width of a 16-foot road. Practically, however, due to the overhang over the wheels, these trucks might be placed on the pavement so there would be a 2-foot clearance between the bodies, provided each truck went to the extreme edge of the pavement in passing. This, however, is not often the case, due to the fear of getting too close to the edge of the roadway, and the uncertain condition of the shoulder. For this reason it can readily be seen why most States have already relegated to history the 16-foot roadway, and adopted 18 or 20 feet for the width of a double-track road.

For a two-track roadway nearly all States are now advocating 18 feet with a minimum of 3 feet of shoulder on each side. A few of the States still adhere to a roadway of 16 feet, but in this case, shoulders are always provided which the traffic may readily use if it is necessary.

For a road of three traffic lanes many States adhere to 24 feet in width, but there seems to be a growing opinion that this should be increased to 26 or even 30 feet.

The reports of the American Road Builders' Association, covering this subject of widths, recommend that double-traffic trunk highways should be at least 20 feet wide with a minimum width of shoulder of 5 feet. Nine feet should be added to the width of the roadway for each additional line of traffic. Wherever the right of way can be acquired, provision shall be made for shoulders of at least 9 feet in every case. This is for the purpose of future widening of the roadway when necessary.

#### LAWS OF TRAFFIC.

To widen the roadway to certain limits is a step in the ideal direction, but it can not be said that a roadway should be widened without limit, for after a certain width is reached and traffic becomes heavy, the width may be more intensively used by establishing separate lanes for the fast and slow traffic.

The cost of the road enters strongly into the determination of width, and when the compromise is made the minimum should be sufficiently wide to take care of the lines of ordinary traffic, plus as much clearance width as the importance of the road and the intensity of the traffic justifies.

Regardless of width of roadway, the shoulders should be maintained in a serviceable condition for cases of emergency. If the roadway is not sufficiently wide to provide for traffic, the shoulder will receive considerable of this traffic and cause excessive maintenance. Many times, this excessive maintenance would pay the cost of construction of wider roadway, which would result in a much lower shoulder maintenance and provide a more satisfactory pavement.

In level countries where alignment is straight and curves are flat, there seems to be no necessity for an increase in width from the general widths required for the various numbers of lines of traffic, but in countries where the alignment is not straight, it is quite essential that the width on all curves of 10° and over should be materially increased.

The increased width should be added on the inside of the curve and begin at a point ahead of the point of curvature and extend beyond the point of tangency. The additional width required varies according to the degree of curve and local conditions.

Many States after deciding upon their unit of width have made their width of road entirely dependent

upon the amount of traffic. Where there is a traffic of from 3,000 to 4,000 vehicles a day, the roadway is made not less than 18 feet in width; where the traffic includes 5,000 vehicles and more during the day, the roadway is made at least 26 feet and sometimes 28 or 30 feet. Satisfactory shoulders should be provided, to carry the traffic which may be forced off the metal roadway onto the shoulders.

Some States have decided that if a hard-surfaced pavement is to be used, the minimum roadway, in order to provide for a single line of traffic, should be at least 9 feet in width and preferably 10 feet. A pavement of this kind should not be attempted unless there are satisfactory shoulders of sufficient width and character to enable vehicles to pass without danger, or unless turnouts are provided at intervals.

#### THICKNESS.

To make any specific recommendation as to the necessary thickness of the pavement would be attempting to solve a problem wherein there are two or more variables, for the thickness of a pavement not only depends upon the demand of traffic that the pavement may be subjected to, but also depends upon the type of pavement and the conditions of the subgrade and drainage system, which influence not only the strength of the pavement, but its resistance to withstand the numerous and varying loads. Practically all failures of the old pavements that were designed to withstand merely the demands of the lighter vehicles, were due to the wear of the surface. As the loads upon these pavement were increased, the pavements broke down under the overload, and were thus prevented from wearing out in the old way. This would seem to indicate that a pavement possessing the quality of tensile strength which will enable it to act as a beam is demanded.

Pavements are called upon to withstand compressive stresses, to resist tensile stress, set up, when the pavement is subjected to beam action, and to resist shearing stresses. It seems that most of our pavements have been so designed as to withstand the compressive and shear action, but the greatest trouble has been found in attempting to design a pavement that will withstand stresses when the loads bring about beam conditions. Of course it will be a simple matter to design a pavement that will act as a beam and withstand any load, provided it is not necessary to keep in mind the necessity of keeping the cost within moderate limits. In order to limit the necessary thickness of pavement to a minimum, considerable effort has been made in the way of distributing the weights or forces over a large area.

Other experiments have been made using a cushion to overcome impact.

Almost the first step in designing a pavement must be to assume the nature and condition of the subgrade; the better the subgrade, the thinner it is possible to make the pavement.

As the conditions of the subgrade become worse, the thickness of the pavement must be increased, so that on account of the changing conditions of the subgrade our first assumption is full of variables. Generally the design is not changed for each condition of subgrade, but the worst place is considered and the entire pavement designed from these conditions; this, of course, is uneconomical.

The ideal limit would be to have a perfect subgrade so that only a thin road surface would be required. As the subgrade becomes worse in character, the thickness of the road surface must be increased for the purpose of distributing the loads over a wider area. A popular method of load distribution has been the use of a rigid base such as concrete.

While in many designs it is assumed that the stresses travel from the load to the subgrade along lines inclined at angles of  $45^\circ$  to the surface, actual experiments show that in a concrete surface, the lines of stress reach as far as 6 feet from the point of load application; this means that the load is sometimes distributed over a 12-foot area.

Now the problem is to design the road to take care of compression, punching shear, and beam action. Taking into account the distribution of stresses produced by the load, either a concrete pavement, or a pavement with a concrete base, surfaced with bituminous material, will provide the necessary compressive strength, and the minimum of design, supported by a satisfactory subgrade, has always been ample to provide for punching shear, as our problem seems to be the design of a surface that can withstand the tensile stresses which are developed when the road acts as a beam. Designing on this basis, we find ourselves at a loss for assumptions. The span can hardly be assumed to be identical with the total limits of the load distribution; generally the span would be much shorter. But even if the span were considerably shorter, the designing of this pavement as a beam would be almost prohibitive in cost.

It has been computed that in a pavement designed as a beam to withstand a 20-ton truck, the reinforcement would cost between \$2 and \$3 per square yard. This of course is prohibitive, and even if we assume the best subgrade conditions to exist, our reinforcement would cost about \$1 per square yard, and then we would not be taking care of our worst conditions.

### BETTERMENT OF SUBGRADE.

It therefore remains for us to look about for ways of designing the thickness of pavement other than by greater thickness of substances like concrete or by the use of heavy reinforcement.

About the only other place to look for a betterment is in the subgrade. We can see that if the subgrade is perfect, only a very thin surface will be necessary and it is only when the subgrade is weak that a thicker surface becomes necessary. Is there not some way, then, in which we can improve our subgrade and thus avoid the necessity of increasing the thickness of the pavement surface?

At the present time, we artificially drain our subgrade to a limited extent. Further draining would assist toward bettering the subgrade. To complete this operation and bring the subgrade to a nearly perfect condition, the use of a layer of crushed stone 2 or 3 inches in thickness spread over the subgrade and connected to all the drains, is recommended. Such an expedient would improve the firmness of the subgrade, and if the thickness of pavement surface is dependent on the character of the subgrade, the thickness of the surface would be thereby reduced considerably. It would seem that an economic pavement would be one of a material such as concrete laid on a carefully prepared subgrade, designed as previously described. If it be desired to absorb the shock of excessive impact such a pavement could be covered with a bituminous surface. This would mean a bituminous mat that would absorb impact and transfer the loading to the concrete, which in turn would distribute the load over the prepared subgrade. When the subgrade is prepared as described, there will be slight chance of its shifting, which would mean that the span between supports will be small, and will further mean that a much thinner concrete distributing layer can be used.

In order to crystallize the points of this paper on line, grade, width, and thickness, the following conclusions may be drawn:

**Alignment.**—On scenic roads the straight line is not absolutely necessary but careful attention should be paid to safety. On commercial roads the straight line is ideal and all roads should approach this alignment.

**Grades.**—While the grades on scenic roads should be held low wherever possible, the ideal grade on a commercial road is the level grade. Whenever a road surface is changed from earth or macadam to hard surface, the grade should be materially reduced if it is desired to retain the advantage of a hard surface.

**Width.**—The minimum width of a two-way traffic road should be at least 18 feet, an additional width of 9 feet should be added for each line of traffic, and suitable shoulders should be provided in all cases. After four or five lines of traffic have been thus accom-

modated the width should not be increased, but instead lanes for the separate lines of traffic should be constructed. All curves sharper than  $10^\circ$  should be widened and banked.

**Thickness.**—While thickness is dependent on the type of pavement and the nature of traffic, it is also closely identified with the condition of the subgrade. Bettering the subgrade affords the means of reducing thickness of pavement, which seems to indicate it might be more economical to spend money preparing subgrade than to attempt to support the loads by blindly increasing thickness.

### DISCUSSION OF MR. UPHAM'S PAPER.

F. R. ROGERS, State highway commissioner of Michigan: We can not go back of the elementary principles discussed in Mr. Upham's paper. I am going to confess a few mistakes we have made in Michigan, with some suggestions as to what we are thinking about doing to remedy those mistakes.

As you all know, one of the counties in Michigan has become quite famous for its concrete roads. We began by building concrete roads 16 feet in width, 6 inches thick. We have discovered they are not wide enough. We have had to add bituminous shoulders on the side. There is not any doubt in my mind but the shoulder upkeep on those narrow roads has cost enough since they were built to have widened them at least 2 feet on each side; so, had we looked ahead as far perhaps as we should, we would have built wider roads.

In Michigan, on the more important roads which we are paving, we are building at least 18 feet wide, and in some rare cases 20 feet. There is one in Detroit County that is 24 feet wide. That has been criticised by some engineers. Perhaps it was a mistake to build 24 feet. It perhaps was not much improvement over the 20-foot road. That road is asphaltic concrete of the Topeka type, with binder course, the base is 7 inches thick, the binder  $1\frac{1}{2}$  inches, and the concrete top  $1\frac{1}{2}$  inches. We rather think it will hold the traffic, because it was laid on an old base that was formerly gravel, into which some crushed stone had been injected. It was thoroughly scarified and widened, and there has not been much disturbance of the base.

I have in mind roads that have been built on sandy soils, one in particular on what was probably the ancient shore of Lake Huron. That road is only 6 inches thick and has not broken off at the joints, which practically substantiates, I think, what Mr. Upham has said about preparing a first-class base if we expect the roads to stand up.

We built two years ago, or a year ago this last summer, under war conditions, about 10 miles of concrete in Monroe County over a soil that does not lie

so very high above Lake Erie, a clayey loamy soil, in fact, the worst kind of clay I know of. There are quite large side ditches, yet that road has constantly broken through under traffic. I am not quite positive, but I think the minimum thickness is 7 inches, with 8 inches in the center. And frequently when it begins to give, apparently pumping the water from the sub-soil below (I do not remember the side drainage) we find a puddle under the surface failure. I am inclined to think that the treatment suggested by Mr. Upham of a subbase of macadam connected with a side drain, might have overcome that. We did find, however, that a piece of that road that was started on a sub-grade prepared the year before, failed very much less than that constructed on the new subgrade.

So far as we are concerned, wherever we expect to pave, if there is much disturbance of the subgrade, or much cutting or filling, we are trying to do that work one year in advance of the paving, notwithstanding it makes it necessary to let a contract for cutting and drainage structures and later a contract for paving. I heartily agree with what Mr. Upham said about widths. We are a little bit at sea as to when we ought to build wider than 18 feet.

Mr. Fletcher told me an interesting thing that I have sometimes thought of to prevent breaking at the edges and particularly breaking at each side of the expansion joint on the edges. The elimination of the expansion joints will probably do away with that, but Mr. Fletcher says he is putting a  $\frac{3}{8}$ -inch rod about 2 inches from the edge in the center of the slab which will reinforce and perhaps prevent breaking off. I asked him whether it was in the bottom or top and he said, "We don't know which way the stress is going to be, so we are putting it in the middle."

I think, in many cases, we build, not with a factor of safety, but with a factor of ignorance. I think there are a whole lot of things about road building that we do not know, and I do not think I can add anything to the knowledge that has been given.

#### ENGINEERS MUST DO IT.

JAMES ALLEN, highway commissioner, Washington: A location may be dear at \$75 or \$100, and you may be merely wasting money; while on the other hand it may be economical at \$400 a mile. You can not say a location should cost \$100 a mile; you can not say it should cost \$400.

I heard Mr. P. J. Pogue say once, "The most important work, as I see it to-day, for engineers starting on this great program of highway building, is for the engineers to do it." That is what I think. If the engineers are not capable of doing it, God knows the lawyers and doctors and bankers are not.

The alignment comes first and is most important. In heavy mountainous country you can not get perfect alignment. Do not pay any attention to the

right of way; you will find all your right-of-way troubles come right at first. I venture to say that 75 to 90 per cent of our right-of-way troubles were never reported; they were compromised. In the State of Washington we have never yet had a jury award more damage for a right of way than our right-of-way agent offered the man; and in a lawsuit they don't get half or a third of what was offered.

Every highway out in Washington must be hard-surfaced. We can not get away from it. Gravel roads and other cheap types of roads are out of it. The alignment must be made right, as nearly right as possible. That is most important. I do not see how you are going to lay down any hard and fast rule for plans and specifications. You must study your road.

Mr. MACDONALD: I am glad that Mr. Allen has spoken out in meeting and put the responsibility for the kind of roads we build squarely up to the engineers. In the past we have had to occupy a more or less apologetic attitude toward the public because we wanted them to go down into their pockets and put up a considerable amount of money for us to spend. We have that money now and we do not want to lose sight of the fact for one instant that the public is going to place the responsibility upon us for the kind of roads that are built. It may be that we may have considerable pressure brought to bear upon us from the doctors and lawyers and even from our commissioners, but with all due respect to these gentlemen, the engineering features are for engineers. It is a fortunate engineer who has a commission composed of business men, or lawyers, or doctors, or any other class of men, who recognize that they have engineers employed to advise them, who hold the engineers responsible for the engineering work, and follow their advice.

I do not believe that Mr. Allen accented too strongly the point that when it comes to the building of the roads and the choosing of the type of roads to build the highway engineers that are in this room are going to be held accountable. You can not pass the responsibility on to your commission or to the public. The engineers now in this room are going to be held accountable for the spending of the money that has been appropriated.

#### KANSAS ROAD LAWS UPHELD.

In a decision delivered January 20 the supreme court of Kansas by a unanimous vote declared that all the road and bridge laws of Kansas were constitutional and valid. The decision places the road program of the State on a sound basis, shutting off much opposition and many suits being planned by those against road improvement under the laws passed in 1917 and 1919.

# Highway Administration.

GEORGE H. BILES, Assistant Highway Commissioner of Pennsylvania.

**H**IGHWAY administration, in the several States, is for the most part in charge of commissions, appointed by the several governors, who select their assistants, with their varying responsibilities, or a single commissioner, selected by the governor, with his deputies, chief engineer, and other assistants.

Either form if composed of men endowed with vision, imagination, and force, given to a determination to administer impartially and efficiently, all other things being equal, will succeed. Starting out, as many of us are to-day, with the responsibility for the expenditure of millions of dollars of public money, let us not lose perspective but work on a broad comprehensive scale, planning for the greatest good to the greatest number. Three contributing factors to this end are control, confidence, and courage.

Control, in the strictest sense of the word, should be exercised by centralized executive authority. The execution of our plans with intelligence, fairness, and dispatch will win public confidence, without which we will fail. The utmost courage to do the right thing in spite of the selfish aims and importunities of individuals or communities is required in the disbursement of public money.

## CONFERENCE AND COOPERATION.

I am a firm believer in the wisdom of doing things through conference with our business associates and with the counsel of others. Many organizations depriving themselves of such counsel become affected with individualism, which usually begins at the top and results in a contraction or narrowing of the whole organization. This creature, obsessed with the idea of its own importance and sensitive to its prerogatives, ignores and resents the counsel of leaders of men and thought until too late, when it is enveloped.

One of the basic principles in the creation of an organization is to obtain zealous and efficient men, responsive at all times to the demands of the situation and working as a team for the realization of the aims and purposes of the executive. Recognition for meritorious service must be given such men, which is possible, only, when salaries are not fixed by statute. Men, under such stress, either go up or out, they can not stop or go stale.

In developing an organization of this kind it is our theory that the State organization should have power to supervise expenditures and operations and extend engineering and advisory assistance to the counties, townships, and towns, to prevent abortions, which are bound to result where innumerable engineers are permitted to operate promiscuously. If there is one



GEORGE H. BILES.

thing that will jeopardize the consumation of a road program it is poor work, which may result from bad engineering or careless inspection. The inspector is the most important individual on the work for upon him depends the success or failure of carrying out the engineer's plans. The inspection force should be composed of fair-minded, intelligent, and practical men, holding allegiance to no one save their superiors, and should be paid a wage commensurate with the importance of the work.

The cooperation of the State creates a sense of security on the part of communities expending large sums of money and is the biggest factor in the success of good-roads campaigns throughout the State. Through such cooperation the comprehensive idea of main primary roads can be extended to the counties on secondary systems, with the ultimate satisfaction of seeing roads built to meet the demands of traffic, and creating a network of uniformly good highways.

Attract to your work strong contracting concerns with ample capital and equipment resource to insure completion of your program. Before work is awarded the contractor's responsibility should be established through presentation of his financial statements and assurances from banking institutions indicating their willingness to extend him assistance, if need be, to

finance the project, accompanied by records of his previous performance in contract work.

A new philosophy can be preached to contractors in this era with surprising and gratifying results. If you can convince men of your fairness and sincerity of purpose, the great majority will be receptive to the suggestion that they must derive some compensation out of satisfaction in doing good work. Upon the award of contract the contractor automatically enlists in the cause, becoming as much a part of the organization as any of its employees, the only difference being that he is paid in units of work while the employee is paid in units of time.

#### MUST HAVE AMPLE POWER.

Prudence demands the passage of laws giving ample power to the organization to prosecute a program, when deemed expedient, with the departments' agents or employees, permitting the acquisition of property and construction of building necessary for the manufacture of any road material entering into the building of a modern highway, which materials may, in the discretion of the department, be furnished to contractors engaged in State road work.

In the administration of highway work on the scale upon which most of our States are launching programs at this time the greatest single requirement is organization and system. If we stop and think of the work units involved in the disbursement of \$1,000,000 for this class of work and multiply this by 40 or 50 or more, as some of us must do, it will be apparent at once that it becomes an undertaking for big business organization and management.

In the first analysis, the duties of the several units of the organization should be grouped on a functional basis, the segregation of the special or distinct functions automatically creating the several separate divisions. Authority should be centralized in the executive head, between whom and the several operating divisions there should be a coordinating branch or body, known as the management division, in charge of an executive manager.

#### DIVISIONS OF ORGANIZATION.

A brief description will be given of the organization and functions of the major divisions of a modern highway department.

**Executive Division.**—The function of this division should embrace the determination of all policies not entering into the details of operation, for which division heads should be held accountable. As an assistance in the determination of policies the executive division should be supported by a strong organization equipped to devise means for the enforcement of its policies, and the coordination of the activities of the department. This responsibility logically is that of a management division, which may be termed the operating branch of the executive division.

**Management Division.**—The functions of this division may be briefly stated as follows: To supervise and place in force the principles of management as applied to all branches of the department; to determine the various operations of the department in accordance with the requirements of the statutes; to group the operations upon a divisional basis for assignment to the proper division and for the creation of the necessary organization therefor, followed by complete instructions; to schedule the performance of all phases of the department's work and disseminate the same graphically and uniformly and to follow up the various schedules presented, investigating all complaints and delays; to be represented at each department conference on investigation and research and to supervise the compilation of its findings, from which standard methods of operation can be devised for all phases of the department's work; to supervise the publication of all bulletins and periodicals upon the work of the department and to present to the executive body and general public the accomplishments of the department at convenient intervals; to supervise the development of future operations; to have control over the system and methods of procedure in all divisions, also office equipment and supplies; to provide for complete records of the personnel of the department and to supervise the work of all subdivisions which involve other subdivisions, whose work is general in its nature. Other responsibilities of this division include the authorization of funds, the compilation of statistics and graphic presentation of them.

**Purchasing Bureau.**—Some of the important questions handled by this bureau are the location of materials, grade of supplies, quantities available, shipping conditions, traffic regulations, local conditions affecting prices and storage facilities.

**Contract Bureau.**—A large construction or maintenance program involves the preparation of contracts and agreements which should be handled by a branch of the organization especially equipped with legal knowledge.

**Equipment Bureau.**—Systematic inspection with uniform instruction and standard workmanlike repairs to equipment requires an organization of mechanics and inspectors under a competent mechanical engineer.

**Information Bureau.**—The dissemination of information should be in charge of a special bureau in order that the best regulations may be established with the agencies involved, and also that there may be a uniform, and at the same time official, presentation of all information given to the public.

**Stenographic, Typing, and Duplicating Bureau.**—To provide uniformity and equalization of work, stenographic, typing, and duplicating work should be centralized in one bureau.

**Filing and Mailing Bureau.**—Uniform filing and mailing methods requires the handling of work of this kind in one bureau.

**Construction Division.**—The functions of the construction division at headquarters can be grouped upon practically the same basis as the department as a whole with the division of responsibility in accord with such grouping. These groups may be designated as engineering; drafting, and testing. The engineering branch, through its field offices should handle the making of surveys for all road and bridge construction work, also for change of alignment or other special work, as well as the supervision and inspection of construction methods. The drafting branch is concerned with the preparation of plans, the design of structures, and the handling of estimates. The testing branch should handle the checking and testing of materials entering into the construction of projects, together with investigation and research work to establish other sources of material supply.

**Maintenance Division.**—The maintenance division is concerned with the protection, through adequate maintenance, of the investment which has been made for road construction. Thorough instruction of employees, adequate inspection, the preparation of estimates, the authorization of work, the selection of materials and supplies, the shipping and delivering of the same, the securing and distributing of equipment and its operation, and the employment and payment of labor are duties incident to the carrying out of a large maintenance program.

**Township Division.**—This division of a highway organization is of unquestioned value in the service which can be rendered to townships through the assistance offered in the form of engineering advice and supervisory control of road building and maintenance. The approval of contracts for the expenditure of township funds, the enforcement of legislation applicable to townships, the distribution of reward funds, and the issuing of permits for the placing of sub-structures, telephone or telegraph poles and temporary crossings, is placed under its charge.

**Automobile Registration Division.**—The functions of a division for the registration of motor vehicles may be grouped as follows: Receiving, registration, filing, shipping, mailing, and inspection. Among the many operations in handling work of this volume are the sorting, classifying, and examining of mail and receipts and the auditing of accounts. The actual registration requires the typing and proof reading of certificates and the duplicating of ledger sheets and file cards. The filing of copies of the registration certificates alphabetically according to the registrant, and numerically according to manufacturers, and engine numbers are of material assistance in the recovery of stolen vehicles and the apprehension of the guilty parties. The shipping of tags and mailing of registration cards forms a large part of the work of the division. An adequate inspection force distributed throughout the State is essential to the enforcement of the motor laws.

**Auditing and Accounting Division.**—The functions of the auditing and accounting division consist largely of the budgeting and auditing of accounts, and cost accounting. To this end their work should be grouped upon the following basis: Pay rolls, invoices, and expense accounts, bookkeeping, and cost accounting, these branches handling the issuance of checks and all details incident to the payment of labor, the auditing and payment of invoices and expense accounts, bookkeeping and cost accounting, respectively.

The divisions which have been mentioned will in the majority of cases be applicable to most highway organizations, and additional units may be created as the need arises, keeping in mind always the logical grouping of functions, and the establishment of the same principles of control. Thus a department may grow indefinitely and yet preserve its balance.

#### DISCUSSION OF MR. BILES'S PAPER.

C. M. BABCOCK, commissioner of highways, Minnesota: It seems to me it simmers down to the point as to what are the duties of the highway department, before you can determine the policy of administration. Mr. Biles, in his paper, referred to the passage of laws giving power, when deemed expedient, permitting the acquisition of property and the construction and the building necessary for the manufacture of road material. I don't believe that the function of the highway department is that of manufacturing any materials that enter into the road construction problem.

One of the greatest difficulties is not in getting materials; it is in having those materials hauled by the railroads. Therefore I maintain that if it is necessary at this time for us to enter into the manufacture of road building materials it is doubly important that we go into the construction and actual building of the railroads in order to get materials on the roads so we can build our highways.

It seems to me that the duties of the highway department should be confined to the actual construction of the roads, the acquiring of the rights of way, the building and construction of highways and the structures incidental thereto. When we accomplish that and assume that burden in the various States, it seems to me that we have placed upon our shoulders one of the largest responsibilities there is any State department to-day. In trying to shoulder upon the highway departments the manufacturing and the building of road materials, as well as the handling of automobile road construction, we are doing wrong in my estimation. I believe, as stated before, that those things should be handled by other subdivisions of the State departments, and not by the highway department. The highway department should confine its

efforts exclusively to the construction and building of highways.

There is a tendency in all highway departments of all States, as well as in Federal departments, to over-organization, and to the creation of too many bureaus. There are too many bureaus within the bureau. What we want is business administration. We want an organization that will handle things in a business way, and efficiently. They should be able to give you the actual cost of the different types of road in different sections of the State. And if an organization is properly organized it will be able to give you that.

#### NEED BUSINESS ORGANIZATION.

In handling our road problems in the various States, it is necessary that we organize on business lines. We are placed in a position of trust. The position is one that involves the expenditure of millions of dollars. Summing it up, as the attorney general said to me back there, "Your function here is simply to see that the State's money and the moneys placed in your hands are not squandered. In other words," he said, "You are to see that you give the public dollar for dollar for all the money that passes through your hands."

That is a large responsibility, but it places itself right back on the same basis as any business organiza-

tion. Take the banking business, for instance: You people invest your money in the banking business. You put a man in charge of that bank. You expect that man at all times to safeguard your principal? Yes. And what else? You also expect him to return you a dividend at the end of the dividend period, and if he doesn't do that, what do you do? You immediately "chop off his head" and employ some other man.

If we do not handle our road proposition in such a way as to get results what will happen? The fact that large sums of money are being appropriated is not in itself sufficient for the building of roads. The fact that we have millions of dollars down at Washington, have millions in various State treasuries, available for road purposes, does not better the condition of the road one bit until the contracts are let and the roads are actually built.

It is results the public demands. It is not the acquiring of large sums of money, it is results, the finished product. And it is the finished product we have to have. That is what we must look forward to, not to the creation of bureaus within bureaus, and the overorganization of our departments. That is not the idea. What we must have, in my opinion, is the simplest form of organization, strictly along business lines.

## A National Program for Highway Research.

ANSTON MARSTON, of the Iowa State Highway Commission, Ames, Iowa.

#### AGENCIES FOR HIGHWAY RESEARCH.

**T**HERE is very urgent need for the immediate inauguration of scientific highway research in accordance with a comprehensive National program. The country is about to spend untold billions of dollars in the construction of paved roads. Yet there is a very serious lack of the fundamental scientific data which are absolutely essential to the correct design and construction of paved roads. In this respect we are still in the situation of the bridge engineers prior to 1850, who were building bridges without knowing how to compute the stresses in the different members; or in the situation of the sewerage and drainage engineers, who have learned only within the last few years how to determine the weights which must be carried by sewer pipe and drain tile laid in ditches.

The stresses in pavement slabs due to traffic, the effect of impact and abrasion, of variations in temperature, of nonuniform foundations, the cost of the various elements of highway transportation and the effect upon each element of each item of road improvement, all these and many other fundamental things require very extensive scientific experimentation to develop the true foundation principles of really scientific highway engineering.

(a) The American Association of State Highway Officials has already taken measures to coordinate highway research by the various State highway departments by establishing a test and investigation committee, which is already organized and which has been doing some very good work this year.

Undoubtedly every State highway department is a potential agency for important highway research, and no National program for such research can be made successful without the cooperation of the highway departments.

(b) The United States Bureau of Public Roads.—The United States Bureau of Public Roads is undoubtedly spending more money at the present time in direct scientific highway experimentation than any other agency. The work in devising instruments for measuring stresses in pavement slabs and in the subgrades, and the actual measurements of the effect of impact, etc., are already of great value.

(c) The road laboratories of engineering colleges and engineering experiment stations.—Many of these laboratories are well equipped and can undoubtedly be enlisted in a highway research program.

As illustrating such work already under way, it may be said that the Iowa Engineering Experiment Station is required, by State law, to spend at least \$10,000 annually of its funds for road experimentation, and that it is actively engaged in a research on the determination of all elements of cost of highway transportation and the effect upon each element of cost of highway transportation of each element of road improvement, upon which investigation it proposes to spend at least \$7,500 per year for a period of several years.

(d) Municipal testing laboratories are available in a number of large cities which could do valuable work.

(e) Manufacturers' research departments and associations should be able to render valuable assistance.

(f) Commercial laboratories.

(g) Technical societies.—The great National engineering societies can render effective assistance in organizing a national program, and in determining the use to be made of the scientific data to be secured.

(h) Consulting highway engineers.

It must be apparent that there is need for coordinating these eight research agencies in order to insure covering the entire field of highway research adequately and without unnecessary duplication of effort.

#### A PLAN FOR A NATIONAL PROGRAM.

A number of conferences have recently been held by representatives of highway laboratories, of State highway departments of the United States Bureau of Public Roads, and of the National Research Council, at which a tentative outline plan for a national program of highway research has been evolved.

This tentative plan is to organize six research committees, each to have charge of a definite line of highway research, and each committee to have representatives from all the various agencies to be enlisted and from all sections of the country.

Each of the eight research agencies in this country, as enumerated above, will of course take active part in organizing the national program of highway research (otherwise it could not be a success), and the cooperation of the engineering division of the National Research Council has been asked.

The National Research Council has been organized by the National Government for the general purpose of organizing and coordinating scientific research of this character. The engineering division of the research council has acted favorably upon the general plan here outlined, and I speak as a representative of that division, as well as a member of this association, in presenting the plan at this time.

#### COMMITTEES RECOMMENDED.

The six highway research committees recommended are as follows:

(1) Committee on the economic theory of highway improvement.—Purpose: Determination of all elements of cost of highway transportation (both motor vehicle and animal drawn) and the effect upon each cost element of each element of highway improvement (improved surface, grade reduction, elimination of rise and fall, etc.) to enable reliable and scientific determination of the sums which could be economically expended for specific highway improvements.

(2) Committee on structural design of roads.—Purpose: Experimental determination of stresses, strains and behavior, of impact and abrasion, in actual roadways under actual traffic, including also the effect of temperature variations, freezing and thawing, non-uniform subgrades and other factors, in order to establish reliable scientific theory for the structural design of roads.

(3) Committee on properties of road materials.—Purpose: To investigate the properties of road materials and their combinations, including devising and standardizing tests.

(4) Committee on methods of road construction.—Purpose: To collect and disseminate information on the various methods of securing efficient results in road construction, under various conditions and in the different parts of the country.

(5) Committee on maintenance methods and design.—Purpose: To collect and disseminate information on the various maintenance methods and the principles of maintenance design which are found to give best results under different conditions in the various sections of the country.

(6) Committee on highway bridge and culvert research.—Purpose: Investigation of the waterways required for different classes of culvert and drainage areas. Investigation of the distribution of wheel loads over bridge floors. Other unsolved problems of highway culverts and bridges.

The author believes that the executive committee and the tests and investigations committee of the American Association of State Highway Officials should now proceed to cooperate actively in organizing and making a success of some national program of highway research, such as outlined, or some other practicable program in which all the research agencies can be enlisted. The organization of each committee should be worked out in such a way as to provide adequately for representation from the State highway departments of the country, as determined by the executive or tests and investigations committees. There are very many ways in which the many State

highway departments can cooperate in the actual researches. In fact, many of the researches can not be made successfully without the active cooperation of the State highway departments. There are many data needed which can be collected best by them. Our executive and tests and investigations committees should (and I think they do now) have full authority to act for us in cooperation in a national program of highway research.

#### DISCUSSION OF MR. MARSTON'S PAPER.

L. I. HEWES, Bureau of Public Roads: Are there not two general categories into which all questions of highway engineering may be placed—those that are economic and those that are technical? And is it not true that the engineer in the past has almost completely neglected the economic side of his profession, and is that not one reason why he has held a subordinate place in the larger generalship of those matters with which he has to deal?

In the matter of financing highways, the question was never raised to my knowledge as to how much a given community could afford to invest in its highways. The question was never raised as to the term of the bond and for years they adopted the suggestion of the bankers that a 30-year bond for highways was the desired term. If you will examine the statistics you will find that the banker suggested a bond which gave him the maximum profit. After the 30-year period he could hardly demonstrate to the public that it was advantageous to them to continue the life of the bond, but he showed that upon that bond there was a great diminution in the amount of the sinking fund required per year; he didn't tell you how much interest you were paying. You know now that it is not a good policy to run bonds beyond 15 years, and probably not beyond 10 years, in order that you may have an asset behind your liability. That is an economic question which the engineer completely neglected.

#### IMPORTANT ECONOMIC QUESTIONS.

There are other important economic questions. For example, one has been raised this morning with reference to the bonding of contractors. It has been said here time and again that this body of men has to spend the greatest amount of money that any single body of men has ever been called upon to expend, yet they are willing to relegate the determination of the amount of the bond to outside people without taking a slide rule and computing what is an equitable charge on these bonds.

The relation between the cost of construction and the cost of maintenance has not been given sufficiently sincere consideration by these people who are building the roads. There is no enthusiasm about maintenance. There is a great deal of enthusiasm about

new construction. What is the proper relationship between the amount of money we should spend and the amount we should reserve for maintenance?

How this program is going to hold in 10 years is another economic question. We have at least 5,000,000 motor vehicles. They have cost \$1,000 apiece, which represents \$5,000,000,000 invested in rolling stock on our highways. They tell us that the machines are junked once in 5 years. But suppose they are only junked once in 10 years? Suppose the junking process is due only 50 per cent to the roads? See how much that is, and capitalize it, if you please. How much can you afford to spend to avoid having that waste by improving your highways? Those questions are economic ones.

I don't believe we know enough about the construction of concrete roads. I think Mr. A. N. Johnson published a table in the Engineering News-Record recently in which he showed 30 different mixings of concrete, using gravel and broken stone as aggregates. We need to know the effect of bulk and waste on concrete and bituminous structures. We are almost in total ignorance.

#### QUESTIONS TO BE ANSWERED.

The question is continually raised about impact on the road. We do not know anything about rolling friction. If you will look up the literature on the subject in any library you will find it is almost a total blank. Some of you who were at Detroit at the convention some years ago probably saw that machine which tested competitive types of pavement by pounding them with a horseshoe. We didn't foresee then that that horseshoe was to be taken off the pavement. We have a condition to-day which approximates a plane surface on which we are rolling cylinders. If a wheel is a perfect cylinder and the road is a perfect plane, how will you get impact?

The question has been raised, What is the economic depth of concrete roads? I think Mr. McClintock, of Massachusetts, was the first man in the United States to segregate road stones into different sizes, and he must have been forced to choose the size of stones by their relation to the thickness of the road he proposed to build. Are there any governing factors in the size of the aggregate? Considering that for a moment in relation to the recent discussion regarding the area theory in the use of cement, ask yourself the question: Couldn't you use 4 or 5 or 6 inch aggregates and build roads beyond all possibility of breaking up while using no greater amount of cement?

Now the question of width. It is surprising that a body of technical men should be so under the influence of conditions. What has determined the width? The width has been determined by the gauge of the old farm vehicle and the one-horse chaise. We are going to spend billions of dollars and be responsible not

merely for not keeping up with things, but for not having foreseen things. The question is, How wide should we build our roads? That has been touched on only very lightly.

If we can not answer these questions, then why should we complain if commercial interests and other interests come to us and say, "This is what you shall do."

#### TO MAKE RESULTS KNOWN PROMPTLY.

Mr. MACDONALD, Chief of Bureau of Public Roads: In discussing the nation-wide program of research, a number of the executive officers of highway departments have found it somewhat difficult to enthuse very much over such a program because of their fears that if this program were handled by a national committee the results would be delayed until after the roads are built. I believe it would be well if Mr. Marston would define what function the National Research Council proposes to exercise in connection with such a program, and make it very clear that the results, however obtained, will be immediately available; and that the National Committee on Research is not to be particularly a reviewing body, or the investigative body, but simply the correlating body.

Mr. MARSTON: What we propose is best explained perhaps by taking up the case of one of these committees, say, that which has to deal with the experimental investigations of pavement slabs, which has been mentioned. A chairman would be selected and on that committee would be appointed members representing the various agencies which could be induced to undertake the work, representing different sections of the country.

Certain work on that particular subject is already underway on quite an extensive scale. Such work will continue as a part of the program of this committee. The bulletins giving the results of all work will be published as often as there is anything to publish, perhaps more frequently than annually, so results will be available immediately.

The National Research Council merely fulfills the function for which it was organized by the United States Government, that of taking the initiative and of coordinating the work of all investigators, so that they will not cross each other's field, and so that the whole field will be covered adequately. The results are to be taken right off the griddle, as it were, as the meal proceeds.

## Shall Contract Bonds Be Eliminated?

W. G. THOMPSON, State Highway Engineer of New Jersey.

ONE of the reasons advanced for the elimination of contract bonds is that they cost a great deal, and, in the opinion of one of my correspondents, are unnecessary to a very large extent. For instance, a contract for which the contract price is, say, \$300,000, will in most States require a bond for the full amount of the contract, or a \$300,000 bond. That costs the contractor a considerable amount of money, and is bound to be included in his contract price when he bids. No man is going to assume an obligation of perhaps \$1,000, \$2,000, \$3,000, or \$4,000 on a contract and not make the State or the governing body pay for it.

The argument has been advanced that you always have sufficient money withheld from the contractor to paralyze him if he withdraws from his contract or performs it in an unsatisfactory manner. In New Jersey we withhold 20 per cent of each monthly payment until the completion of the work. So you see we are quite well protected up until the end of the job. Really, on a \$300,000 contract, we have \$60,000 withheld. Now, a reputable contractor would be quite jealous of his reputation in the first place, even if there were no compelling clause, and in the second place he is going to think a lot about giving up \$60,000 which is the withheld percentage on the \$300,000 contract.

It seems to me the subject is very well worth serious consideration. Some of our members here have said that they do not wish contract bonds eliminated,

however. When we consider the enormous expenditure now in prospect for highways during the next two or three years, the percentage of the total amount to be paid by governing bodies for the privilege of exacting the full amount of the contract as a bond will cost the State a great deal of money.

There has been up to date, of course, in most localities an insufficient number of reputable contractors to carry on this work. This is because of the fact that the programs have grown so rapidly that contractors in other lines of work have been unable to adapt themselves to the new conditions, and are therefore not altogether competent to carry on highway construction properly. Yet with the experience and training of the past two years we are getting together a pretty fair aggregation of highway contractors.

With these premises I present the subject to you. As I see the matter, we are to offset the rather vague advantage of requiring the full amount of the contract as a bond for proper and faithful performance against the enormous cost to the State that is absolutely lost to the ultimate object of road construction. It will undoubtedly amount during the next five years to hundreds of millions of dollars worth of actual road construction lost to the State because of the money paid the contractors for the bond requirement.

#### DISCUSSION OF MR. THOMPSON'S PAPER.

FRANK R. ROGERS, State highway commissioner, Michigan: We have had more or less trouble with the

matter of bonds. As a matter of fact, I might say that we are required in Michigan to take one bond from a contractor, which is a statutory provision, guaranteeing the payment for labor and material. We can not eliminate that. The law says nothing about the size of the bond, or whether it shall be a surety bond or a personal bond.

We have some difficulties with the bond companies. In the first place, regardless of the size of the bond, they figure the fee on the size of the contract. If it is a \$100,000 contract, and we only exact \$20,000 bond, they charge 1½ per cent on \$100,000, yet assume no liability beyond the size of the bond, which is very unfair.

We have found it necessary or at least advisable in certain instances to take personal bonds in small matters such as small bridges for instance. We have a line of contractors who are good mechanics. They have not a very great capital, and the hardship of a surety bond sometimes is considerable. In the first place, the surety companies insist on having enough money behind the contractor (either of his own or his friends) to guarantee the surety company before they put up a bond to guarantee the State. That does not work very well.

Up to date, I will say frankly, we have had as much trouble with surety bonds as with personal bonds, if not a little more. The matter of personal bonds is more serious in a local community, where the bonds are for persons who have friends who can make their influence felt in the common council or county board than in State work, where the person bonded has no such friends at court.

We may have some trouble with personal bonds on a few contracts. It is pretty hard to strip a man of all he has when he has given a personal bond, and you do not feel that way about the surety-bond companies. However, our experience is that the surety companies are past masters in taking advantage of every detail. If there is a slip anywhere they know how to get out of the responsibility. So there is more or less trouble that way.

It is a pretty hard problem. I put up to our advisory board at the first meeting the question of the possible unfairness involved in exacting a surety bond in some instances and in other cases taking a personal bond. I asked them if we should lay down an ironclad rule in all cases. I told them about the small contractor and our troubles, that it might eliminate the small contractor entirely; that, in fact, it would be impossible to get contractors to bid on certain jobs if we required a surety bond. They decided we had better use our judgment as in the past.

#### NOT WISE TO ELIMINATE THE BOND.

It is a seriously complicated and difficult question, although it never occurred to me that there was any possibility of getting away from the bond entirely,

and I do not think it would be wise in our State. We couldn't do away with it entirely, and I don't think it would be wise to leave out the bond for the faithful performance of the contract, although we seldom take a bond for more than 50 per cent of the main contract; and if it is a contract which is largely a labor proposition, and very little material is purchased from a distance, so that freight charges are small, we sometimes make that bond as little as 25 per cent of the contract.

GEORGE E. JOHNSON, state engineer, Nebraska: We do not think it wise to discontinue the bonding of contractors on highway work, for two reasons, one that appears ridiculous. In the first place, we get a good deal of the money you fellows put into bonds; in the second place, a bond is a form of insurance against possible loss, and if you carry the principle of discontinuing bonds through the whole matter of contracting you will come to the conclusion that you do not need any insurance at all. It is perfectly true many of us never collect from bonding companies. But once in a while we do get caught very badly. The State of New York during the last two or three years has been caught by unreliable contractors on a number of occasions. For these reasons I think the use of surety or personal bonds is advisable.

GUY MILLER, Bureau of Public Roads: I think as much of the trouble in New York was due to war conditions as to unreliability of contractors. Having figured up the premiums they have been paying, and the cost the bond companies have put them to in court, and having balanced those against the recoveries from the bond companies, New York is now accepting a bond for 50 per cent and withholding 10 per cent of the contract as the monthly payments come in; or, at the option of the contractor, they will not require a bond, but in that case will withhold 20 per cent. As I see it, it is a matter of balancing of cost. They figure the cost will be less by the new plan than by continuing bonds.

Mr. JOHNSON. As soon as we adopted the policy of allowing personal bonds the bond companies came down a half a cent on contracts.

#### TOO MUCH PAID OUT FOR BONDS.

Mr. COYKENDALL, engineer of road management, Iowa: We require surety bonds for anything above \$1,000. I suspect that some of the bond companies' agents boosted that law. It is, at least, a very good one from their standpoint. We have seriously considered the advisability of legislation allowing the State to carry insurance. Of course that is something we would have to get through the legislature, but it looks as if the expenditure for bonds is entirely out of proportion to the protection they give us.

With the projects we have on hand we can well afford to carry insurance. We have also considered the possibility of getting up a black list of contractors that are inclined to take advantage, if the bond provision should be stricken out of the law. If that is done, it would be well, we think, to attempt working the same kind of arrangement with other States. But,

as indicated before, we are paying out of all proportion to the value received from the bonds.

H. J. KNUELLING, construction engineer, Wisconsin: If all these large manufacturers can carry their own fire insurance, and a great many carry life insurance for their men, I can not see any reason why the State is not big enough to be its own insurance company.

#### SURETY AND PERSONAL BONDS.

M. W. TORKELSON, bridge engineer, highway commission, Wisconsin: The Wisconsin Commission has had quite a battle over this question of bonds. We have adopted the scheme the past year of admitting either surety or personal bonds—that is, we determine whether or not we will permit a man to give a personal bond. On a considerable part of \$1,000,000 worth of work 56 per cent had surety bonds, and 44 per cent had personal bonds. We look up the Dun or Bradstreet rating of the man before we will accept a personal bond. We think that, with the amount of work we are handling, we are just as able to do that as a bonding company is.

Our trouble with surety bonds is the very large charge the surety companies must make to cover overhead expenses. We have found that some of the old-line liability companies have overhead expense for agents' commissions and other purposes amounting to 45 per cent, that never goes into protection at all. For some mutual companies such expenses run as low as 13 per cent. For that reason we have been encouraging our contractors to use the mutual companies for liability insurance, and there are some mutual companies that are as reliable as old-line companies.

There is one advantage, however, of the bond in the surety company. A poor contractor can not get a bond. In that way the surety-bond requirement helps to eliminate some of the overzealous fellows who want work and are not able to do it when they get it.

There is another point that is sometimes overlooked which is illustrated by a contract we had for \$200,000. The rate was 1½ per cent, which would make the cost of the bond \$3,000. The contractor wished to sublet the major part of that work. As our State doesn't recognize a subcontractor, the bond of the subcontractor had to read "direct contractor," and the subcontractor had to pay 1½ per cent, making the amount the State finally had to pay on that bond 4 per cent or over, depending on the amount of the subcontract. The rates sometimes run higher than a bonding company will admit.

In a series of years of work there have been only two cases in my experience where a bonding company has been called on to pay. We have three, I think, we will lose now. If you add up the losses you have with the premiums you have paid, I think you will get extraordinary results.

J. H. MULLEN, chief engineer, Minnesota: We pay between \$150,000 and \$175,000 a year on surety bonds in Minnesota. I don't believe we have had recoveries from the bonding company to exceed \$3,000 or \$4,000 a year. We have not had to go to the bonding companies to collect on a bond. There has been a waste of over \$100,000 a year, I believe. Mr. Thompson's idea is good; we could carry our own insurance to good advantage, paying a little more attention to the responsibility of the contractor, his resources and ability to handle the work, and devise some other

means than exacting 1½ cents on every dollar's value in a job.

#### AMERICAN RAILROAD ASSOCIATION TACKLES THE CAR SERVICE PROBLEM.

The commission on car service of the American Railroad Association has issued the following circular, CCS-7, in regard to car service for the transportation of road-building materials.

##### TO RAILROADS:

Information reaching the Bureau of Public Roads of the United States Department of Agriculture, from various State highway commissions, and from producers of materials used in road construction, indicates that there will be an extraordinarily heavy movement of these materials during the coming season. It is estimated that the road building this year will not be less than three times that of the heaviest previous season. The transportation demand will be accentuated by reason of the fact that much of the road construction will be in territory where stone, sand, and gravel deposits are so located as to require abnormally long hauls.

It seems to be apparent, from what has already been brought to our attention, that the handling of this business will require some cooperative action between individual railroads and the commission on car service in order that maximum use of equipment and adequate service for this traffic may be secured. It is suggested, therefore, that individual carriers should, as promptly as possible, ascertain the demands that will be made upon them, and in the event that relief seems necessary, the commission on car service should be promptly advised of all the facts so that the necessary steps may be taken looking to such readjustment of car movement as is possible in individual cases.

W. C. KENDALL, *Chairman.*

State highway departments and county and municipal road and street officials can render invaluable assistance to the railroads and, at the same time, promote their own interests, by at once notifying their local railroad officials, as to the probable tonnage of materials they will require during the coming construction season.

The commission on car service is a body which has been formed, since the return of the railroads to private ownership, by the American Railroad Association. In large measure, it will take over the duties of the former car-service section of the division of operation of the United States Railroad Administration. The new commission is composed of W. C. Kendall, chairman, A. G. Gutheim, W. J. McGarry, and W. L. Barnes.

Already by a joint agreement with the principal railroads of the country, the commission has increased the per diem rates on freight cars in transit on freight rails from 60 cents to 90 cents per day. By this means it is hoped to speed up the transportation business of the country so that the shortage of cars, amounting to about 80,000 monthly, may be at least partially overcome.

As a further means of speeding up the freight transport facilities of the railroads the commission has recently held conferences with superintendents of transportation and of railroad yards.

# STATE TESTING ENGINEERS AND CHEMISTS MEET IN WASHINGTON.

**D**URING the week of February 23 a meeting of State highway testing engineers and chemists was held at the Bureau of Public Roads in Washington under the auspices of the committee on tests and investigations of the American Association of State Highway Officials. The purpose of this meeting was to formulate standard methods for testing road materials, to standardize methods for sampling, and to establish safe test limits for incorporation in specifications.

Prof. T. R. Agg, chairman of the committee on tests and investigations of the American Association of State Highway Officials, acted as chairman of the conference.

Those present were:

T. R. Agg, consulting road engineer, Iowa Highway Commission, Ames, Iowa.

B. A. Anderton, chemist, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

R. H. B. Begg, professor of civil engineering, Virginia Polytechnic Institute, Blacksburg, Va.

J. G. Bragg, senior testing engineer, New Jersey State Laboratory, Quarry Street and Taylor Place, Trenton, N. J.

L. G. Carmick, assistant chemist, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

W. F. Cooper, office engineer, Louisiana State Highway Department, New Orleans, La.

R. B. Dayton, testing engineer, West Virginia State Road Commission, Mechanical Hall, Morgantown, W. Va.

A. W. Dean, chief engineer, Division of Highways, Department of Public Works, State House, Boston, Mass.

R. B. Gage, chemical engineer, Taylor and Quarry Place, Trenton, N. J.

A. T. Goldbeck, engineer of tests, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

J. F. Grimes, assistant road engineer, Frankfort, Ky.

H. B. Hinderlite, Raleigh, N. C.

G. W. Hutchinson, testing engineer, State Highway Department, Dover, Del.

F. H. Jackson, senior assistant testing engineer, Bureau of Public Roads, Washington, D. C.

F. C. Lang, engineer of tests and inspection, University of Minnesota, Minneapolis, Minn.

H. Walter Leavitt, testing engineer, Maine State Highway Commission, University of Maine, Orano, Me.

Frederick T. Maddocks, testing engineer, California Highway Commission, Forum Building, Sacramento, Calif.

W. D. Martin, Columbus, Ohio.

Henry M. Milburn, chemist, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

W. F. Purrington, chemist, New Hampshire Highway Department, 19 Thorndike Street, Concord, N. H.

A. S. Rea, engineer of tests, State highway department, Brown Hall, Columbus, Ohio.

F. L. Roman, testing engineer, Department of Public Works and Buildings, Division of Highways, 820 East Adams Street, Springfield, Ill.

F. C. Rossell, chemist, Maryland State Roads Commission, 601 Garrett Building, Baltimore, Md.

R. L. Saunders, deputy state highway commissioner, State Highway Commission, Hartford, Conn.

R. A. Seaton, professor applied mechanics, in charge road materials testing laboratory, Kansas State Agricultural College, Manhattan, Kans.

E. B. Smith, senior assistant testing engineer, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

D. V. Terrell, professor of civil engineering and testing engineer, University of Kentucky, State Road Department, Lexington, Ky.

Malcolm H. Ulman, chemist, Pennsylvania State Highway Department, Harrisburg, Pa.

M. O. Withey, testing engineer, Wisconsin Highway Commission, Madison, Wis.

The conference was divided into four committees:

1. Committee on tests of concrete and concrete materials.
2. Committee on tests of other nonbituminous materials.
3. Committee on tests of bituminous materials.
4. Committee on test limits for specifications.

As a result of the conference standard methods of sampling and testing bituminous and nonbituminous materials were adopted and a report of the committee on test limits for specifications was received, although not adopted by the conference.

During the progress of the conference the following papers were presented on subjects that seem to be of special interest at this time:

Penetration Limits for Asphalts for Different Types of Construction. By Prevost Hubbard of the Asphalt Association.

Blast Furnace Slag, by the Slag Association. Read by Mr. W. D. Brewer.

The Fineness Modulus Method for Proportioning Concrete. By Prof. D. A. Abrams, Lewis Institute, Chicago, Ill.

It is expected that the proceedings of this meeting will be available for distribution in bulletin form some time in the near future.

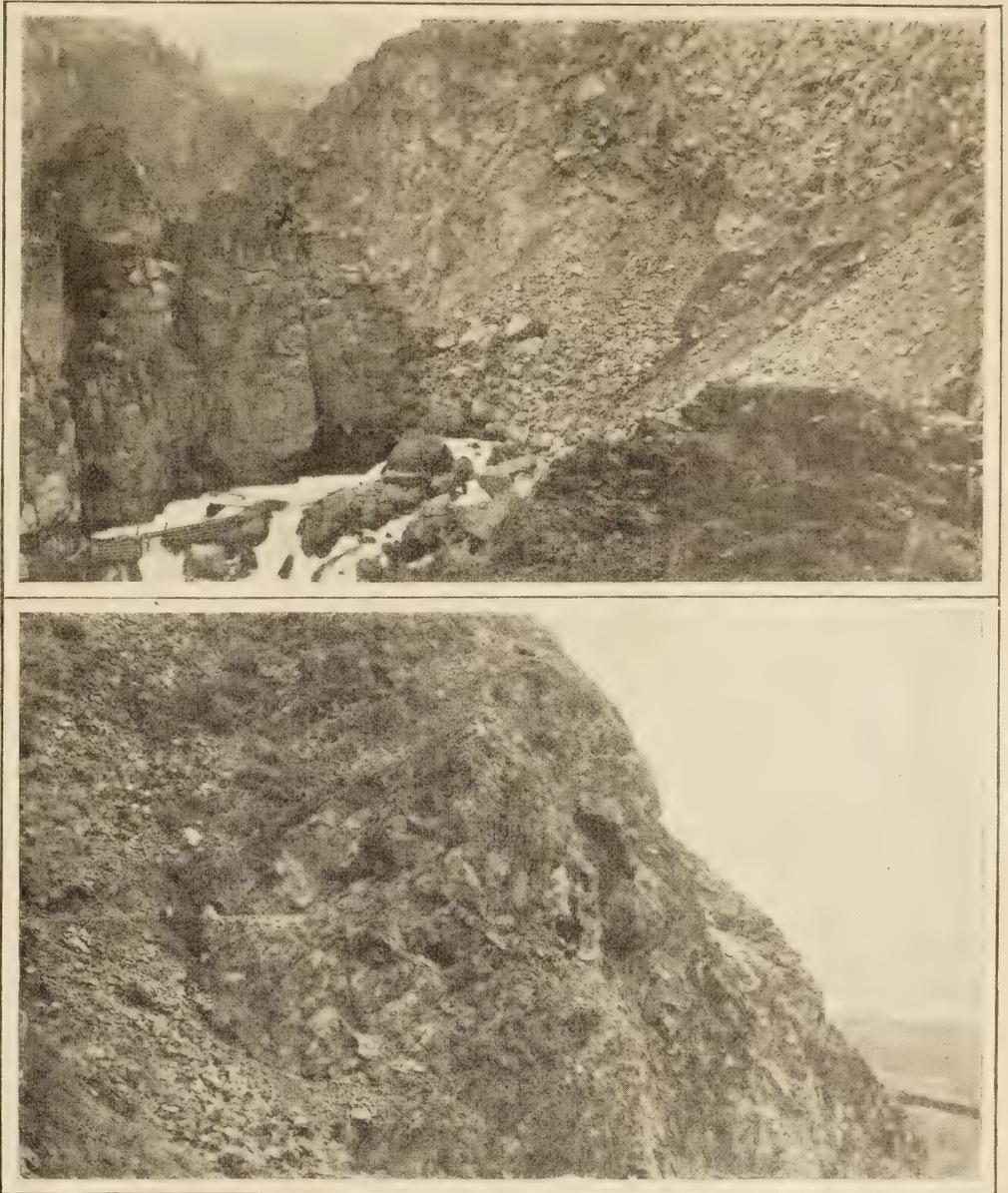
# INTERESTING FEDERAL AID PROJECT.

**I**N THE building of highways as in other classes of construction work the unusual is always of interest. It is the tallest building, the biggest ship, the longest bridge, which attract attention, and justly so, for such works are measures of unusual attainment and, as such, are powerful stimulants urging others to equal or to greater effort.

One, therefore, looks for the unusual in highway construction, not because it has any special bearing on the every-day activities of the highway engineer, but because successes under difficult conditions are a measure of the courage and of the resourcefulness of the men who have dared to push forward in the face of unusual difficulties. If it were not for such men the profession would lag, and if it were not for knowledge of the works which they have constructed, courage to go forward would often be lacking.

Such projects as Washington Federal aid project No. 45 are, therefore, of special interest, for to attempt the unusual requires courage and resourcefulness

and to succeed in the attempt implies skill as well. This project is not a long one. Indeed, it involves the building of only a little over 2 miles of roadway. Nor is the purpose of its construction unusual. A lake of rare beauty, large forests, wonderful hunting and fishing, in short, all of the delights that nature can put in a single region lie at one end of the route; at the other, a prosaic railroad station. Between there is a rough and rugged mountain. For years all who have gone to the lake from the station have climbed this rugged mountain. It is true that there has always been another way, for the river which runs out of the lake long centuries ago cut a path through the mountain. But no one went by this way; the sides of the river gorge were too steep and the river itself too deep and too dangerous. It remained, therefore, an untraveled way, but it will remain so no longer for the Washington



ON FEDERAL-AID PROJECT NO. 45, WASHINGTON. TOP, CROSSING OF CHELAN RIVER. BOTTOM, HEAVY ROCK WORK NECESSARY.

State Highway Commission, when it decided to develop a road from the station to the most attractive summer resort in the State, had the courage to build the road where no road had ever gone before, to blast a place for it in the solid rock sides of the river gorge.

To record the fact that to build it there means to move more than 80,000 cubic yards of material, over half of which is solid rock, would be to infer that such projects can be measured in tons of material or in dollars of cost. But they can not be so measured. It is not the rock that is moved or the money which is spent that renders such projects monumental, but the daring and the imagination of the engineer who is willing to cut a new trail where none has ever been before, because, as an engineer, he believes the new location to be the proper one.

# GRAPHICAL PROGRESS REPORT IN FEDERAL AID ROAD CONSTRUCTION.

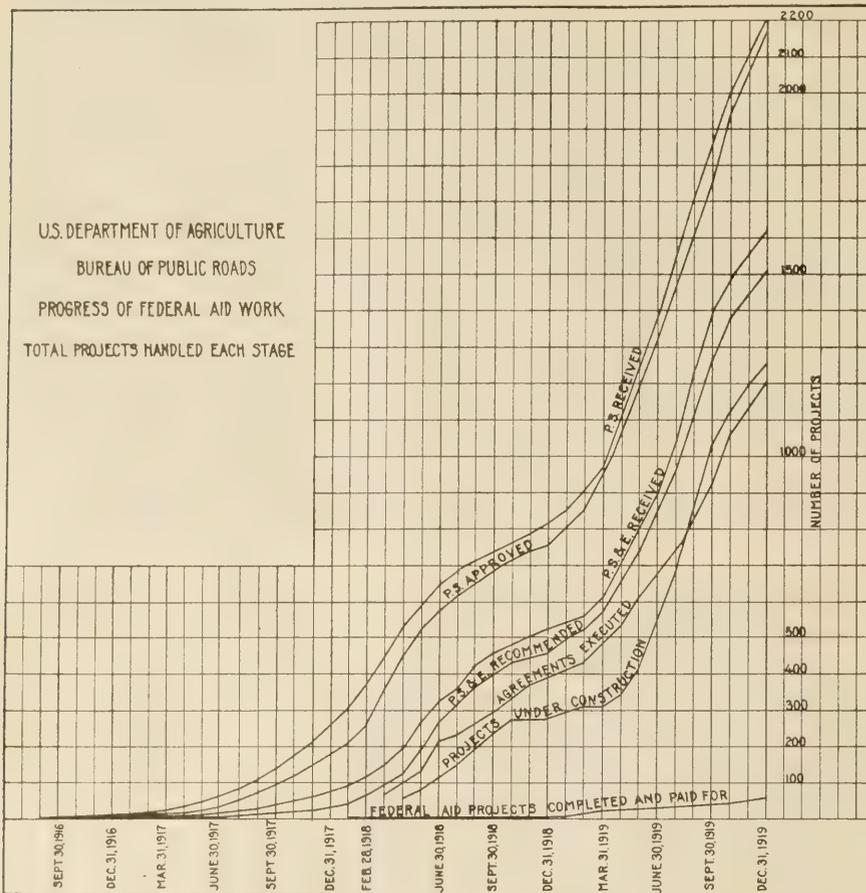


CHART SHOWING PROGRESS OF FEDERAL-AID WORK.

**W**HAT is virtually a complete summary of the operations of the Federal Government and the States under the Federal aid road acts of 1916 and 1919 from the passage of the first law to the close of the calendar year 1919 is contained in two charts recently prepared by the Bureau of Public Roads.

The first chart, reproduced here as figure 1, shows the progress of Federal aid work by numbers of projects in the various stages from the initial project statement stage to the final completion and payment for the work.

This chart traces the development of this important work through the early days of comparatively small accomplishment, when appropriations were small and the States and Federal Government were laying the foundation for the great cooperative work which was to follow; through the lean years of the war when road building was put aside for the more important business of war; and through the period of accelerated accomplishment which, following immediately after the armistice and gathering new momentum from the passage of the second act on February 28, 1919, continued through the past year.

On December 31 last the States had filed 2,243 project statements of which 2,173 had been approved. Work on over 1,600 projects had proceeded to the stage at which the plans, specifications, and estimates are delivered to the Bureau of Public Roads; and project agreements had been actually executed and construction work was in progress on 1,200. In the meantime, however, work had been begun on about 50 projects for which agreements had not actually been signed, thus expediting the progress of the work.

The projects actually completed and paid for are comparatively few, but they are materially exceeded in number by those which are practically completed. The coming year should develop a sharp rise in the curve representing the completed projects, as these projects are finally cleared and credited to the record.

One of the most significant facts brought out by the chart is the great reduction which has been made in the amount of time required for the preliminary work before actual construction work is begun. By closer

cooperation and improved facility in handling the necessary preparatory work, this period had been so reduced that, at the height of the last construction season, it was little more than one-half as long as it was in the early stages of the work.

For those who are interested in the performance of particular States the second chart, figure 2, will contain interesting information. The various symbols show the total apportionment of Federal money to each State available prior to June 30, 1920, and the amounts of such money covered by project statements submitted and approved; plans, specifications, and estimates recommended; and project agreements executed; and finally the amounts actually paid on vouchers to the States prior to December 31.

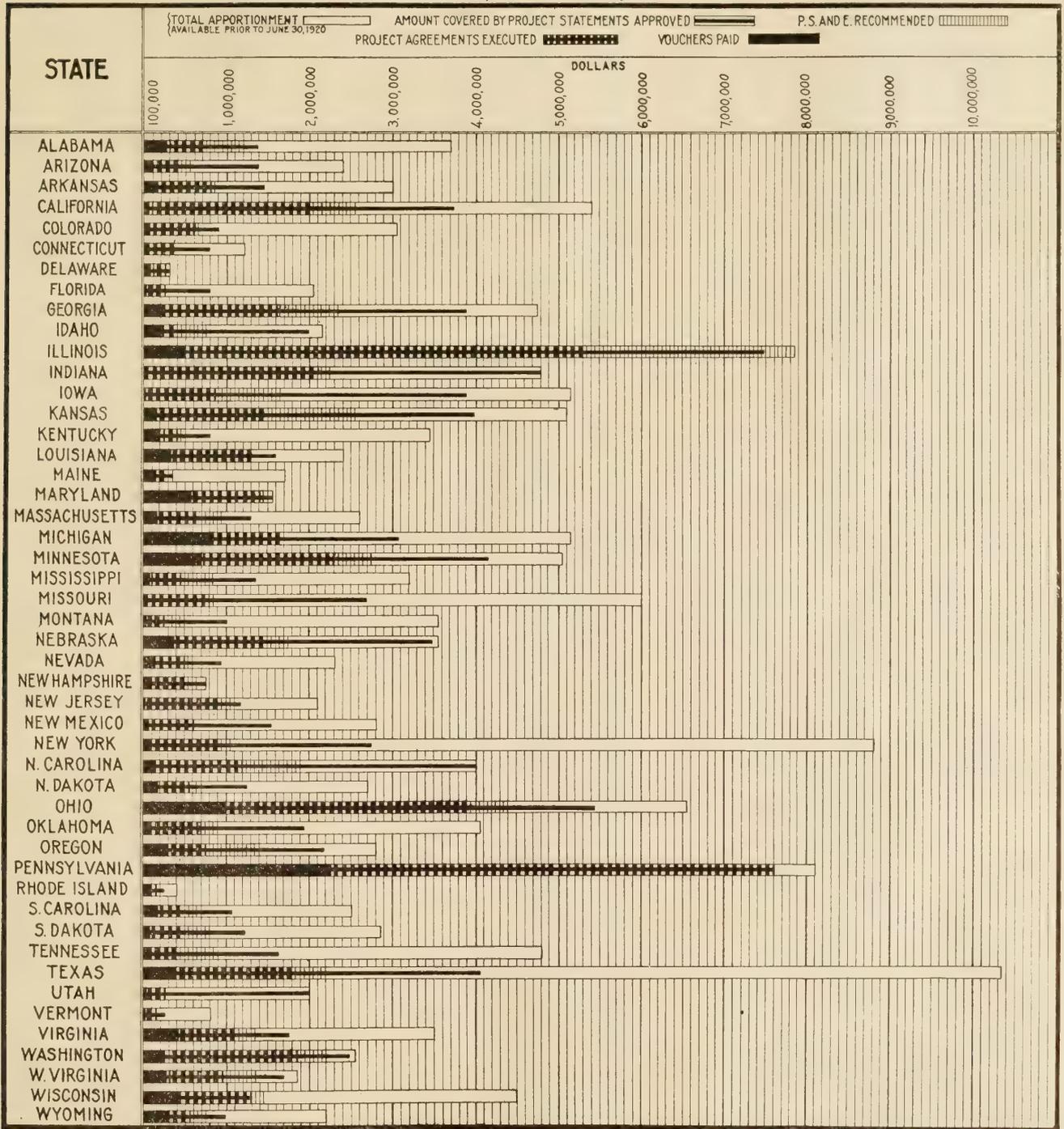
The average State has submitted approved project statements for about five-eighths of its allotment, and has entered into agreement to construct highways which will call for about one-third of its Federal aid money. Vouchers have actually been paid this average State in the amount of less than one-tenth of its allotment. It should be remarked, however, that this latter figure is no fair indication of the value

of the work which has been completed, as many of the States have funds which are so ample that they are able to carry on the work without requesting payment by the government while the work is in progress.

ware, Illinois, Indiana, Maryland, New Hampshire, Ohio, Pennsylvania, and Washington, all of which have submitted approved project statements for all or nearly all of their allotments, have entered into

### STATUS OF FEDERAL AID FUNDS BY STATES

(ON DECEMBER 31, 1919)



As work is finished which is now nearing completion, and the States' shares of Federal funds are paid, this figure should show a large increase.

The outstanding performances are those of Dela-

ware, Illinois, Indiana, Maryland, New Hampshire, Ohio, Pennsylvania, and Washington, all of which have submitted approved project statements for all or nearly all of their allotments, have entered into agreements for about one-half or more of the funds available, and have actually received payment for work to the amount of from one-eighth to three-eighths of their total allotments.

# DECEMBER AND JANUARY FEDERAL AID.

FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR DECEMBER, 1919.

State.	Number of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Arkansas	34	Cross	2.55	Gravel	Dec. 2	\$26,427.50	\$13,200.00
	37	Washington	14.35	Macadam	Dec. 5	47,099.80	15,000.00
	40	Hempstead	9.51	Gravel, macadam	Dec. 22	63,789.00	19,000.00
	45	Lonoke	6.49	Gravel and asphalt	Dec. 10	72,467.34	21,000.00
	50	Phillips	7.94	Warrenite on concrete base	Dec. 12	224,565.00	36,800.00
	54	do.	7.71	do.	Dec. 22	195,025.60	30,000.00
	55	Prairie	2.09	Gravel, macadam, and asphalt	Dec. 26	30,093.05	5,400.00
	56	Cleveland	4.00	Gravel	Dec. 23	18,541.60	8,700.00
	61	Benton	23.14	do.	Dec. 20	70,796.12	34,500.00
	39	Riverside	14.33	Concrete	Dec. 27	347,765.00	173,882.50
California	41	Imperial	14.86	do.	do.	348,496.50	174,248.25
	29	Jefferson	1.946	Earth	Dec. 26	58,708.76	29,354.38
Colorado	31	Arapahoe	1.17	Cement concrete	do.	43,957.10	21,978.55
	82	Jefferson	23.01	do.	do.	86,646.85	43,323.42
Georgia	109	Dawson	7.00	Sand-clay or topsoil	Dec. 20	51,564.34	20,000.00
	118	Fannin	3.50	Sand-clay	Dec. 26	31,600.80	15,000.00
	119	Pickens	8.00	Gravel or crushed stone	Dec. 20	48,239.44	15,000.00
	120	Carroll	8.10	Topsoil	Dec. 26	59,856.50	15,000.00
	121	Randolph	6.00	Sand-clay	Dec. 27	34,650.85	15,000.00
Iowa	122	Grady	do.	Bridges	Dec. 23	23,760.00	11,800.00
	124	Washington	5.75	Sand-clay	Dec. 27	43,816.85	20,000.00
	65	Boone	22.50	Gravel	Dec. 10	132,558.25	66,200.00
	74	Clayton	32.20	Earth	Dec. 23	160,050.00	80,000.00
	38	Greenwood	5.90	Bituminous macadam or concrete	Dec. 12	275,484.00	58,500.00
Kansas	39	Crawford	5.00	do.	Dec. 10	270,892.09	75,000.00
	40	do.	12.00	Brick or concrete	Dec. 23	722,645.11	180,000.00
Kentucky	9	Todd	1.85	Macadam	Dec. 22	149,714.91	124,857.45
	16	Warren	2.75	Asphalt or bituminous	Dec. 8	50,000.00	25,000.00
Louisiana	23	Lafayette	10.42	Gravel	Dec. 10	129,897.53	64,938.76
	51	St. Charles	6.23	do.	Dec. 23	62,531.15	31,265.57
Michigan	38	St. Clair	16.614	Concrete	Dec. 10	554,070.00	277,035.00
	43	Muskegon	21.892	do.	Dec. 12	728,068.00	364,034.00
Minnesota	65	Benton	5.00	Gravel	Dec. 22	28,215.00	14,107.50
	80	Polk	11.85	do.	Dec. 3	68,714.80	34,357.40
	97	Olmstead	14.54	Concrete, brick, or asphalt	Dec. 22	554,267.90	163,280.37
	100	Steele	8.10	Concrete, brick or asphalt	do.	258,682.60	70,604.78
	113	Crow Wing	3.41	do.	Dec. 16	118,831.68	35,649.50
Mississippi	114	Sherburne	9.50	do.	do.	297,222.20	89,166.66
	80	Adams	3.60	Gravel or sand-clay	Dec. 26	28,715.50	14,357.75
Missouri	84	Jefferson	35.35	Gravel	do.	367,284.72	183,300.00
	32	Gentry	4.12	do.	Dec. 16	84,475.05	42,237.52
	48	Platte	8.22	Brick on concrete foundation	Dec. 8	462,485.37	171,900.00
	50	Harrison	6.62	Earth	Dec. 23	65,619.40	32,809.70
	51	Howell	40.00	Gravel	Dec. 20	186,598.50	93,299.25
	52	Cape Girardeau	3.22	Concrete	Dec. 2	102,530.68	51,265.34
	53	Lawrence	22.00	Gravel	Dec. 26	82,999.89	41,499.94
	54	Gentry	8.58	Bituminous macadam	Dec. 12	181,537.40	90,768.70
	56	Jasper	4.00	Concrete	Dec. 26	88,000.00	44,000.00
	58	Butler	24.00	Gravel	do.	268,323.00	134,161.50
Montana	59	do.	13.00	Gravel and concrete	Dec. 30	80,344.00	40,172.00
	65	Teton	38.00	Gravel	Dec. 12	208,885.60	104,442.00
Nebraska	115	Platte	3.00	Concrete	do.	106,099.40	53,049.70
	118	Thayer and Jefferson	24.50	Earth	Dec. 16	91,245.00	45,622.50
	121	Perkins	17.80	Earth and sand-clay	Dec. 4	63,725.20	31,827.60
	122	Gage, Johnson, and Powell	33.90	Earth	Dec. 26	109,043.00	54,521.50
	124	Dave and Sheridan	34.40	Earth, sand-clay and gravel	Dec. 20	140,043.20	70,021.60
	127	Custer	23.40	Earth and sand-clay	Dec. 24	77,198.00	38,599.00
	130	Cheyenne	33.80	do.	Dec. 8	137,038.00	68,519.00
	131	Pawnee and Richardson	24.10	Earth	Dec. 10	82,137.00	41,068.50
	134	Seward	17.90	do.	do.	63,717.50	31,858.75
	26	Washoe	do.	Bridge	Dec. 26	74,855.00	37,427.50
Nevada	27	Clark	do.	do.	Dec. 23	153,168.40	76,584.20
	39	Quay	1.00	do.	Dec. 8	129,800.00	64,900.00
New Mexico	24	Herkimer	1.06	Bituminous	Dec. 27	176,300.00	138,150.00
	31	Schuyler and Seneca	11.70	Cement concrete	Dec. 26	468,000.00	234,000.00
New York	33	Schoharie	10.34	Concrete	do.	413,600.00	206,800.00
	36	Broome	4.40	do.	do.	176,000.00	88,000.00
	40	Oswego	9.70	do.	do.	388,000.00	194,000.00
	41	Orleans	2.05	do.	Dec. 2	82,000.00	41,000.00
	79	Cleveland	1.65	Concrete or bituminous	Dec. 10	45,730.96	22,865.48
	80	Montgomery	29.70	Topsoil	Dec. 8	323,825.92	161,912.96
	82	Davidson	5.70	do.	Dec. 23	39,607.26	19,803.63
	84	McDowell	28.50	Sand-clay, topsoil, gravel, or shale	do.	346,354.25	173,177.12
	85	Davie	8.252	Topsoil	do.	43,421.40	21,710.70
	90	Pamlico	12.60	Concrete or other hard surface	do.	231,497.20	115,748.60
North Carolina	91	Surry	10.60	Topsoil	Dec. 26	72,294.53	36,147.26
	92	do.	10.85	do.	Dec. 23	89,952.28	44,976.14
	93	Franklin and Warren	23.00	Topsoil, sand-clay	do.	95,960.92	47,930.46
	94	Mitchell	10.00	Bituminous	Dec. 10	113,084.40	56,542.20
	96	Yancey	3.00	Sand and gravel	Dec. 26	35,373.80	17,686.90
	98	Lee and Moore	34.80	do.	Dec. 30	239,398.28	119,699.14
	99	Chatham	34.80	Topsoil	Dec. 23	273,531.28	136,765.64
	100	Avery	21.00	Macadam and gravel	do.	229,735.00	114,867.50
	101	Randolph	19.30	Topsoil	Dec. 26	226,633.00	113,316.50
	107	Madison	3.00	Gravel or sand-clay	do.	48,507.03	24,253.51
Ohio	69	Allen	3.14	Macadam or bituminous	Dec. 4	91,000.00	45,500.00
	74	Hardin	8.05	Bituminous or concrete	Dec. 10	228,000.00	114,000.00
Oklahoma	106	Jefferson	1.071	Brick	do.	59,400.00	29,700.00
	107	Warren	6.865	Bituminous	Dec. 4	187,000.00	93,500.00
Oregon	22	Comanche	6.00	Gravel	Dec. 8	76,096.50	38,048.25
	23	Pushmataha	4.60	do.	do.	65,632.40	32,816.20
South Carolina	23	Lake	1.78	do.	Dec. 12	15,364.80	7,682.40
	38	Umatilla	7.52	do.	Dec. 27	110,771.10	55,385.50
South Carolina	37	Aitken	21.303	Gravel or sand-clay	Dec. 16	128,056.12	64,028.06
	40	Allendale	10.165	Sand-clay	Dec. 12	89,892.03	44,946.01
	44	Clarendon	7.916	do.	Dec. 10	143,183.86	71,591.93
	47	Florence	5.981	Cement concrete	Dec. 23	216,511.75	108,255.87

<sup>1</sup> Revised statement. Figures given are increases over those in the original statement.

## FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR DECEMBER 1919—Continued.

State.	Number of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
South Carolina.....	52	Saluda.....	4.56	Topsoil.....	Dec. 22	\$64,314.44	\$32,157.22
	53	Charleston and Colleton.....		Bridge.....	do	68,129.38	34,064.69
	60	Beaufort.....		do.....	Dec. 26	207,900.00	103,950.00
South Dakota.....	82	Union.....	16.785	Earth and topsoil.....	Dec. 20	93,618.65	33,495.00
	29	Carson.....	9.07	Gravel.....	Dec. 30	46,407.68	23,203.84
	30	Brule.....	8.30	do.....	Dec. 18	72,503.20	36,251.60
	31	Beadle.....	8.50	do.....	Dec. 30	67,875.50	33,907.75
	32	Edmunds.....	16.00	do.....	Dec. 18	131,466.50	65,733.25
	33	Miner.....	11.10	do.....	do	81,339.50	40,669.75
	34	Spink.....	10.90	do.....	Dec. 26	74,053.10	37,026.55
	35	Bon Homme.....	13.75	do.....	Dec. 22	104,579.00	52,299.50
Tennessee.....	21	Carroll.....	12.273	do.....	Dec. 2	201,119.63	100,559.81
Texas.....	24	Marion.....	2.318	Macadam.....	Dec. 27	85,856.28	42,928.14
	113	Hill.....	23.50	Gravel.....	Dec. 2	535,826.02	60,000.00
Texas.....	119	Wichita.....	10.00	Concrete.....	Dec. 3	483,212.40	100,000.00
	122	Hill.....	17.00	Gravel.....	Dec. 30	315,182.23	40,000.00
	123	do.....	12.82	do.....	do	145,370.70	25,000.00
	126	Collin.....	37.75	Macadam and gravel.....	Dec. 26	497,050.40	100,000.00
	127	Gillespie.....	18.90	Gravel.....	Dec. 30	112,378.75	24,000.00
Vermont.....	12	Rutland.....	13.65	do.....	do	302,446.10	151,223.05
Wyoming.....	45	Albany.....	2.705	Local material.....	Dec. 27	28,600.00	14,300.00
	52	Fremont.....	3.988	Sand-clay or gravel.....	Dec. 10	39,600.00	19,800.00
Total.....	119		1,419.99			19,054,127.56	7,798,946.61

## FEDERAL AID, PROJECT AGREEMENTS SIGNED, FOR DECEMBER, 1919.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.	
Arizona.....	9	Pima.....	3.79	Concrete or bituminous.....	Dec. 19	\$116,018.00	\$58,009.00	
Arkansas.....	29	Craighead.....	5.62	Macadam.....	Dec. 26	79,714.80	33,000.00	
California.....	27	Stanislaus.....	12.79	Concrete.....	Dec. 10	257,835.86	128,917.93	
	28	Placer.....	6.68	do.....	do	137,303.70	68,651.85	
Georgia.....	49	Amador.....	10.74	Earth.....	do	71,828.50	35,914.29	
	28	Clarke.....	3.785	Concrete.....	do	83,262.97	41,631.48	
Illinois.....	19	7 counties.....	32.403	Brick and concrete.....	Dec. 30	1,112,096.50	551,108.60	
Indiana.....	29	do.....	25.496	do.....	do	930,063.07	465,031.53	
	16B	Vanderburgh, Spencer, Dubois, Orange, and Lawrence.....	10.275	Brick, bituminous, or concrete.....	do	475,747.10	205,500.00	
Iowa.....	84	Sioux.....	2.94	Brick or concrete.....	Dec. 10	108,185.66	54,000.00	
Kansas.....	1A B	Mitchell.....	4.163	Concrete.....	do	191,607.69	62,445.00	
	21	Allen.....	3.25	Concrete or macadam.....	do	67,073.63	33,536.81	
Kentucky.....	14A	Nelson.....	1.849	Asphalt, rock, or bituminous.....	do	44,444.45	22,222.22	
Maryland.....	7C	Baltimore and Harford.....	.329	Concrete.....	Dec. 23	15,386.25	6,580.00	
	10A	Montgomery.....	2.025	do.....	Dec. 12	91,705.02	40,500.00	
Massachusetts.....	12C	Carroll.....	6.63	do.....	Dec. 10	250,679.23	125,339.61	
	34A	Anne-Arundel.....	5.59	Gravel.....	do	50,097.08	25,048.45	
	14	Barnstable.....	3.331	Bituminous.....	do	52,125.15	26,062.57	
	28A	Berkshire.....	4.899	Concrete.....	do	41,274.75	19,780.00	
	42	Washington.....	7.201	Gravel.....	do	75,243.05	35,000.00	
	61	Freeborn.....	11.53	do.....	Dec. 23	91,116.78	42,000.00	
	69	Rice.....	4.30	do.....	Dec. 26	21,584.29	9,000.00	
	70	Cook.....	4.58	do.....	Dec. 10	38,679.46	19,000.00	
Minnesota.....	73	Crow Wing.....	3.648	Concrete.....	Dec. 12	130,604.87	30,000.00	
	101	Cottonwood.....	8.042	Gravel.....	Dec. 26	66,223.08	21,000.00	
	111	Redwood.....	2.00	do.....	Dec. 27	8,316.00	4,158.00	
	112	Polk.....	1.35	Concrete, brick, or asphalt.....	Dec. 22	31,204.00	19,502.00	
	Mississippi.....	11	Amite.....		Gravel.....	Dec. 12	310,721.26	3,979.00
	Missouri.....	15	New Madrid.....	19.50	do.....	Dec. 23	191,098.16	95,549.08
	Montana.....	34	Yellowstone.....		Bridge.....	Dec. 16	195,477.25	97,738.62
	Nebraska.....	37	Sherman.....	12.05	Earth and sand-clay.....	Dec. 10	83,585.43	41,792.71
	New Hampshire.....	27	Grafton and Hillsborough.....	1.46	do.....	do	30,001.18	15,000.59
		31	Grafton.....	.47	Gravel.....	do	5,417.06	2,708.53
39		do.....	.73	do.....	do	10,077.59	5,038.79	
42		Strafford.....	1.38	do.....	do	12,719.96	6,359.98	
47		Merrimack and Sullivan.....	1.14	do.....	do	17,193.66	8,596.83	
56		Cheshire.....	.71	do.....	do	10,587.06	5,293.53	
60		do.....	1.34	do.....	do	20,333.17	10,166.58	
76		Hillsborough.....	1.12	do.....	do	17,101.48	8,550.74	
78		Rockingham.....	1.444	do.....	do	11,896.11	5,948.05	
82		Merrimack.....	.475	do.....	Dec. 8	9,437.06	4,718.53	
86		do.....	.673	do.....	Dec. 10	7,623.66	2,811.83	
87		do.....	.54	do.....	do	10,174.34	5,087.17	
North Carolina.....	51	Guilford.....	2.26	Asphalt or concrete.....	Dec. 26	66,801.92	33,400.96	
North Dakota.....	53	Lenoir.....	7.234	Concrete.....	Dec. 10	254,789.12	127,394.56	
	55A	Mecklenburg.....	6.004	Bituminous.....	Dec. 23	146,205.60	73,102.80	
Ohio.....	30	Divide.....	10.46	Earth.....	do	31,739.22	15,869.61	
Ohio.....	54	Mercer.....	1.673	Concrete.....	Dec. 3	54,500.00	16,000.00	
	62	Morrow.....	2.553	Bituminous or concrete.....	Dec. 12	91,000.00	40,000.00	
	67F	Logan.....	3.05	Concrete.....	do	123,300.00	52,100.00	
	68Q	Perry.....	1.78	Bituminous or concrete.....	do	51,200.00	25,300.00	
	91	Wood.....	6.741	Bituminous.....	do	148,800.00	37,700.00	
	97	Noble.....	9.462	Concrete or macadam.....	do	220,000.00	67,100.00	
	105	Lucas.....	3.503	Concrete.....	Dec. 27	95,000.00	47,500.00	
	8H	Erie.....	3.488	Cement concrete or bituminous concrete on concrete base.....	Dec. 20	159,633.30	69,760.00	
Texas.....	14	Montague.....	41.616	Gravel.....	Dec. 12	293,635.51	135,000.00	
Texas.....	66	Coural.....		Bituminous, gravel or macadam.....	Dec. 10	31,232.76	32,809.76	
	79	Caldwell.....	6.67	Gravel.....	Dec. 12	10,250.25	5,125.12	
West Virginia.....	38	Fayette.....	5.904	Bituminous.....	Dec. 10	94,587.35	44,000.00	
	42	Raleigh.....	5.142	do.....	Dec. 12	53,350.00	26,675.00	
	59	Jackson.....	.99	Concrete.....	do	34,700.00	17,350.00	
Wisconsin.....	63	Morgan.....	1.36	Bituminous or concrete.....	Dec. 4	42,000.00	21,000.00	
	97	Sauk.....	6.72	Gravel.....	Dec. 26	81,000.00	27,000.00	
Total.....	63		354.96			7,374,590.58	3,412,467.71	

1 9 sections.

2 6 sections.

3 Modified agreement. Amounts given are increases over those in previous agreement signed.

## FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR JANUARY, 1920.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Alabama	73	Choctaw	6.31	Topsoil sand-clay	Jan. 4-6	\$46,172.21	\$23,086.10
Arizona	23	Pinal	32.70	Caliche gravel	Jan. 27	381,264.40	190,632.20
Arkansas	67	Dallas	21.13	Macadam	Jan. 9	70,549.32	30,000.00
	47	Crittenden	15.75	Gravel macadam	Jan. 17	181,589.32	55,000.00
California	40	Shasta	16.84	Earth	Jan. 9	155,650.00	77,825.00
	42	Tehama	15.17	Concrete	Jan. 23	319,137.50	159,568.75
	43	Mariposa	1.28	Earth	Jan. 29	41,206.00	20,603.00
Colorado	38	Morgan	2.727	Concrete	Jan. 9	102,677.71	51,338.85
	32	Adams	6.002	do.	Jan. 23	229,194.35	114,597.17
	23	Delta	5.86	do.	Jan. 29	48,143.42	24,071.71
Florida	20	Duval	12.766	Concrete	Jan. 12	344,035.06	172,017.53
	23	Washington, Holmes		Bridge	Jan. 13	102,872.00	51,436.00
	21	Baker	5.711	Concrete	Jan. 15	183,841.68	91,920.84
	22	do.	8.888	do.	do.	226,898.43	113,449.21
	24	Columbia	9.89	do.	Jan. 31	255,253.35	127,626.67
Georgia	117	Gwinnett	8.00	Topsoil	Jan. 9	61,454.80	25,000.00
	128	Barrow	6.909	Sand-clay	Jan. 23	40,000.01	20,000.00
	126	Madison		Bridge	do.	40,000.42	20,000.00
	129	Clarke	3.80	Concrete	do.	112,992.00	50,000.00
Idaho	32	Clark	10.80	Gravel	Jan. 9	59,998.84	29,999.42
Iowa	49	Emmet	3.95	Pavement	do.	154,670.45	77,300.00
	57	Cedar	24.20	Earth	do.	85,954.00	42,900.00
	86	Jones	25.20	do.	Jan. 12	103,697.00	51,800.00
	64	Jasper	31.50	do.	do.	136,785.00	68,300.00
	80	Ida	19.50	do.	Jan. 5	73,040.00	36,500.00
	87	Muscatine	29.10	do.	Jan. 15	92,653.00	46,300.00
	98	Winneschick	27.20	Earth	do.	149,655.00	74,800.00
	122	Decatur	10.00	do.	do.	63,607.50	31,800.00
	63	Lucas	23.15	do.	Jan. 17	169,125.00	84,500.00
	72	Story	20.50	Gravel	do.	84,634.00	42,000.00
	111	Kossuth	22.31	Pavement	do.	881,565.96	440,000.00
	78	Woodbury	2.80	do.	Jan. 23	120,436.80	56,000.00
	83	Union	24.00	Earth	do.	193,842.00	96,900.00
	120	Jefferson	6.90	do.	do.	45,276.00	22,600.00
	59	Fayette	36.85	do.	do.	140,646.00	70,300.00
	89	Polk	7.22	Pavement	do.	385,832.70	144,400.00
	105	Franklin	9.75	Gravel	do.	68,168.37	34,000.00
	115	Cerro Gordo	22.07	Pavement	do.	974,098.40	441,400.00
	123	Ringgold	12.00	Earth	do.	103,070.00	51,500.00
Kansas	23	Marshall	6.00	Brick or concrete	Jan. 29	226,512.00	113,200.00
	43	Wilson	24.75	Gravel	Jan. 13	601,861.70	147,500.00
	33	Bourbon	12.50	Bituminous macadam	Jan. 15	403,700.00	187,500.00
	41	Atchison	9.38	Brick or concrete	Jan. 23	341,324.50	140,700.00
Kentucky	15	Kenton, Boone	2.109	Concrete	do.	85,789.88	42,180.00
Louisiana	49	Washington	34.97	do.	Jan. 29	421,391.05	210,695.52
	64	Concordia	8.98	Gravel	do.	153,898.54	76,949.27
Massachusetts	29	Hampshire	2.626	Bituminous macadam	Jan. 7	93,115.11	46,557.55
	30	do.	4.238	do.	Jan. 31	154,211.24	77,105.62
Michigan	44	Lenawee	22.505	Gravel	Jan. 23	657,800.00	328,900.00
	45	Ingham	5.48	Concrete	Jan. 29	188,815.00	94,407.50
Minnesota	105	Yellow Medicine	12.32	Gravel	Jan. 6	52,439.20	26,210.60
	104	Renville	3.60	Concrete	Jan. 9	137,772.80	41,331.84
	116	Sibley	1.08	Gravel	Jan. 12	45,440.56	13,632.17
	95	Chisago	19.13	do.	Jan. 14	362,903.20	181,451.60
	103	Renville	3.84	Concrete brick, and asphaltic	do.	148,666.32	44,599.90
	107	Watonswan	14.02	Pavement	do.	473,360.80	142,008.24
	122	Chippewa	12.40	Gravel	Jan. 15	91,319.69	27,395.91
	110	Redwood	10.75	do.	Jan. 17	38,390.00	19,195.00
	118	Carver	19.43	do.	Jan. 15	154,336.60	46,300.98
	126	Rice	3.76	Concrete, brick, and asphaltic	Jan. 17	169,253.48	50,776.04
	134	Jackson	6.00	do.	Jan. 19	229,328.00	68,798.40
	125	Wabasha	2.00	Gravel	Jan. 23	56,292.50	16,887.75
	128	Chippewa	15.00	do.	do.	123,200.00	36,960.00
	127	Stevens	17.46	do.	Jan. 28	128,846.30	38,653.89
	123	Carlton	23.14	do.	Jan. 29	139,299.60	69,649.80
	132	Becker	9.89	do.	do.	65,937.46	32,968.73
	117	Mahnomen	22.35	do.	Jan. 31	124,553.00	62,276.50
	121	Freeborn	10.10	do.	do.	94,336.50	47,168.25
	138	Fillmore	4.34	do.	do.	41,043.20	20,521.60
Missouri	77	St. Louis	15.75	Concrete	do.	685,321.34	326,000.00
	78	do.	6.08	do.	do.	308,123.42	129,850.00
	80	do.	7.06	Concrete	do.	305,401.97	147,250.00
	79	do.	12.634	Asphaltic concrete, brick, concrete	do.	573,585.85	255,980.00
	57	Gentry	10.46	Gravel	Jan. 7	210,946.78	105,473.39
	49	Buchanan	20.40	Concrete	Jan. 12	815,767.92	407,883.96
	55	Lewis	5.50	Gravel	do.	54,999.56	27,499.78
	60	do.	5.70	do.	do.	62,691.64	31,345.82
	62	Marion	10.50	do.	do.	64,543.50	32,271.75
	66	Ralls	13.00	do.	do.	51,480.00	25,740.00
	67	do.	7.00	do.	Jan. 13	27,720.00	13,860.00
	68	Lewis	4.25	do.	do.	44,653.84	22,326.92
	69	Hickory	6.70	do.	do.	36,247.00	18,123.50
	72	do.	8.10	do.	do.	56,140.70	28,070.35
	76	Lewis	6.70	do.	do.	68,016.08	34,008.04
	64	Ralls	7.00	do.	do.	27,720.00	13,860.00
	65	do.	5.50	do.	do.	21,780.00	10,890.00
	61	Jackson	2.10	Earth	Jan. 16	127,798.60	52,000.00
	75	Taney	11.03	Gravel	Jan. 23	20,344.26	10,172.13
	71	do.	1.83	do.	do.	13,019.17	6,509.58
	63	Ralls	4.50	do.	do.	17,820.00	8,910.00
	70	Taney	2.27	do.	do.	10,489.74	5,244.87
	73	do.	2.25	do.	Jan. 31	4,845.46	2,422.73
Montana	64	Cascade	18.00	do.	Jan. 12	103,961.00	51,980.50
	67	Toole	5.00	do.	Jan. 9	41,866.00	20,933.00
	68	Deer Lodge	9.50	Concrete	do.	316,525.00	158,262.50
	73	Cascade	10.50	Gravel	Jan. 23	78,760.00	39,380.00
	44	Gallatin	4.50	Hard surface pavement	Jan. 29	130,565.60	65,282.80
	72	Cascade		Concrete	do.	25,300.00	12,650.00
	56	Park	12.00	Gravel	do.	52,250.00	26,125.00
	70	Silver Bow	12.50	Concrete	do.	398,739.00	199,369.50
Nebraska	138	Sappy	8.60	Earth	do.	31,020.00	15,510.00
New Jersey	23	Mercer	.626	Concrete	Jan. 5	47,295.38	12,520.00
	21	Morris	6.592	do.	Jan. 7	597,917.23	156,840.00
	24	Cape May	5.178	do.	Jan. 9	206,879.17	103,439.58
	22	Mercer	.928	do.	Jan. 12	84,229.48	18,560.00
New Mexico	40	Otero	6.50	Caliche	Jan. 9	15,031.50	7,515.75
	46	Santa Fe	.572	Gravel	Jan. 23	9,481.40	4,740.70
	42	Socorro	17.20	do.	Jan. 29	72,210.60	36,105.30

## FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR JANUARY, 1920—Continued.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
New York.....	38	Sullivan, Ulster.....	11.50	Concrete.....	Jan. 9	\$460,000.00	\$230,000.00
	39	Tioga.....	7.60	do.....	Jan. 12	304,000.00	152,000.00
	35	Jefferson.....	8.50	do.....	Jan. 16	340,000.00	170,000.00
	37	do.....	2.60	do.....	do.....	104,000.00	52,000.00
	42	Delaware.....	5.75	do.....	do.....	230,000.00	115,000.00
North Carolina.....	43	Clinton.....	8.10	Reinforced concrete.....	do.....	324,000.00	162,000.00
	105	Hoke.....	10.00	Sand-clay.....	Jan. 7	81,363.33	40,681.66
	81	Pender.....	27.20	Topsoil.....	Jan. 9	187,296.56	93,648.28
	102	Harnett.....	21.00	Clay-gravel.....	do.....	181,368.00	90,684.00
	103	Duplin.....	11.66	Sand-clay.....	do.....	37,644.75	18,822.37
	104	Chowan.....	20.50	Concrete.....	do.....	426,426.00	213,213.00
	106	Alamance.....	18.00	Topsoil, bituminous macadam.....	do.....	230,639.64	115,319.82
	109	Burke.....	3.60	Topsoil.....	do.....	42,149.25	21,074.62
	110	Orange.....	3.80	do.....	Jan. 12	151,946.85	75,973.42
	112	Caswell.....	11.60	Topsoil.....	Jan. 9	93,434.00	46,717.00
	57	Rowan.....	7.60	do.....	Jan. 23	85,140.66	42,570.33
	61	New Hanover, Brunswick.....	2.31	Concrete.....	do.....	103,248.55	79,500.00
	North Dakota.....	113	Caswell.....	17.60	Topsoil.....	Jan. 27	136,433.00
111		Forsyth.....	13.50	do.....	Jan. 29	72,281.00	36,140.50
57		McLean.....	10.00	Earth.....	Jan. 14	33,000.00	16,500.00
100		Burleigh.....	.....	Bridge.....	Jan. 19	750,000.00	375,000.00
92		Foster.....	4.00	Earth.....	Jan. 27	13,288.00	6,644.00
95		Ramsey.....	12.50	Gravel.....	do.....	56,650.00	28,325.00
103		Eddy.....	4.00	do.....	do.....	22,880.00	11,440.00
24		Garfield.....	9.393	Concrete.....	Jan. 7	400,000.00	200,000.00
21		McIntosh.....	7.451	Gravel.....	Jan. 12	142,277.16	71,138.58
27		Kay.....	2.00	Brick concrete.....	Jan. 29	68,600.38	34,300.19
Oregon.....	36	Wasco.....	7.76	Earth.....	Jan. 12	101,557.50	50,778.75
	35	do.....	9.02	do.....	do.....	317,380.25	158,690.12
Rhode Island.....	7	Newport.....	2.57	Bituminous macadam.....	Jan. 5	109,115.38	54,557.69
	8	Kent.....	4.40	Concrete.....	Jan. 23	242,000.88	121,000.44
South Carolina.....	28	Orangeburg.....	20.34	do.....	Jan. 14	351,986.63	175,993.31
	55	Greenwood.....	18.239	do.....	Jan. 23	214,185.62	107,092.81
	48	Georgetown.....	16.849	Sand-clay.....	Jan. 29	146,227.29	73,113.64
South Dakota.....	25	Brookings.....	12.00	Gravel.....	Jan. 15	92,279.00	46,139.50
	36	Turner.....	17.45	do.....	Jan. 14	158,985.75	79,492.87
	39	Davison.....	15.70	do.....	Jan. 17	114,903.80	57,451.90
	40	McCook.....	17.55	do.....	do.....	128,440.40	64,220.20
	42	Brown.....	21.00	do.....	do.....	182,567.00	91,283.50
	43	Hutchinson.....	18.95	do.....	do.....	149,635.20	74,817.60
	120	Cass.....	12.634	do.....	Jan. 9	104,813.63	52,406.81
Texas.....	124	Hill.....	14.90	do.....	Jan. 5	224,134.90	112,067.45
	130	Kaufman.....	16.09	Gravel, bituminous top.....	Jan. 9	172,000.00	86,000.00
	106	Brazoria.....	9.44	Shell.....	Jan. 29	156,679.57	78,339.78
	49	King.....	4.84	Concrete.....	Jan. 31	187,983.18	93,991.59
Washington.....	84	Preston.....	3.50	Bituminous macadam.....	Jan. 29	63,680.00	31,840.00
West Virginia.....	107	Monroe.....	.88	Concrete.....	do.....	24,000.00	12,000.00
Wisconsin.....	123	Manistowoc.....	3.88	do.....	do.....	132,000.00	66,000.00
	153	Eau Claire.....	4.45	do.....	do.....	17,384.00	8,692.00
	135	Buffalo.....	2.11	do.....	do.....	66,000.00	33,000.00
	136	Vernon.....	2.88	do.....	do.....	90,000.00	45,000.00
	63	Park.....	6.084	Sand-clay.....	do.....	53,790.00	26,895.00
	65	Big Horn.....	3.582	do.....	do.....	31,790.00	15,895.00
Wyoming.....	57	Converse.....	3.562	do.....	do.....	113,795.00	56,897.50
Total.....	162		1,715.82			27,771,696.53	12,452,426.66

## FEDERAL AID, PROJECT AGREEMENTS SIGNED, FOR JANUARY, 1920.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama.....	34	Montgomery.....	.....	Bridge.....	Jan. 6	\$83,564.47	\$41,782.23
	50	Coffee.....	6.41	Sand clay.....	Jan. 17	29,006.91	14,503.45
	53	Coosa.....	3.17	Earth.....	do.....	21,850.46	10,925.23
	54	do.....	1.48	do.....	do.....	12,103.48	6,051.74
	58	Jefferson.....	3.19	do.....	Jan. 23	53,529.13	26,764.56
	55	do.....	5.013	Pavement.....	Jan. 29	190,332.02	95,166.01
	40	Marshall.....	5.60	Macadam.....	do.....	49,921.19	24,960.59
Arkansas.....	56	Jefferson.....	3.82	Pavement.....	do.....	162,815.58	81,407.79
	47	Butler.....	3.37	Sand, clay, or top soil.....	do.....	32,961.02	16,480.51
	32	Hempstead.....	8.07	Clay-bound gravel.....	Jan. 17	76,823.01	38,411.50
California.....	33	Cross.....	4.74	Gravel macadam.....	do.....	41,492.70	20,746.35
	31	Del Norte.....	4.08	Gravel.....	do.....	37,136.70	18,568.35
Colorado.....	18	Humboldt.....	7.43	Concrete.....	do.....	151,646.96	75,823.48
	21	Otero.....	.407	do.....	Jan. 12	16,047.62	8,023.81
	61	do.....	.407	do.....	do.....	16,014.62	8,007.31
Delaware.....	27	Mesa.....	2.265	do.....	Jan. 29	10,801.14	5,400.57
	7	New Castle.....	2.01	do.....	Jan. 17	147,950.55	73,975.27
Georgia.....	39	Laurens.....	.....	Bridge.....	Jan. 6	187,333.75	93,666.87
	68	Walton.....	9.13	Top soil.....	do.....	86,590.35	43,295.17
	76	Wheeler.....	9.87	Sand clay.....	do.....	96,985.13	48,492.56
	41	Douglas.....	6.572	Top soil.....	Jan. 12	40,803.55	20,401.77
	66	McDuffie.....	.677	Sand clay.....	do.....	12,004.39	6,002.19
	100	Terrell.....	13.549	do.....	do.....	80,082.83	40,041.41
	98	Troup.....	5.53	do.....	Jan. 29	70,663.70	35,331.85
Idaho.....	13	Owyhee.....	.....	Bridge.....	Jan. 6	89,980.00	44,990.00
	3	Will.....	16.374	Concrete.....	do.....	507,128.05	253,564.02
Illinois.....	4	Lake.....	19.032	do.....	do.....	757,095.90	378,547.95
	7	Marshall.....	32.613	do.....	do.....	1,301,830.43	650,915.21
	19	do.....	32.625	do.....	do.....	1,443,422.27	721,711.13
Iowa.....	29	Wright.....	14.67	Gravel.....	Jan. 9	161,640.32	80,820.16
	46	Pottawattamie.....	2.65	Earth.....	Jan. 5	26,819.65	13,409.82
	54	Scott.....	8.46	Brick or concrete.....	Jan. 6	379,289.62	189,644.81
	41	Floyd.....	12.40	Gravel.....	Jan. 23	504,290.16	252,145.08
Kansas.....	26A	Rice.....	2.301	Concrete or brick.....	Jan. 29	124,021.35	62,010.67
	37AB	Montgomery.....	3.362	Gravel.....	do.....	75,838.00	37,919.00
	23	do.....	9.876	do.....	do.....	139,171.80	69,585.90
	16A	Rice.....	3.043	Brick or concrete.....	do.....	166,851.74	83,425.87

1 10 sections.

## FEDERAL AID, PROJECT STATEMENT APPROVED, FOR JANUARY, 1920—Continued.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Louisiana	46	Red River	8.05	Sand clay, gravel	Jan. 17	\$77,018.01	\$38,524.00
Maine	4	Penobscot	7.05	Gravel	Jan. 12	106,318.52	53,159.26
Maryland	27	Baltimore	.914	Concrete	Jan. 15	84,365.49	18,288.00
	37A	Kent, Queen Anne	2.00	do	do	61,183.54	30,591.77
	25A	Charles	3.00	Gravel	do	42,672.19	21,336.09
Massachusetts	23	Berkshire	2.124	Concrete	Jan. 6	63,147.75	31,573.87
	26	Franklin	5.134	do	do	279,677.36	102,680.00
	15	Plymouth	4.38	do	do	122,338.70	61,169.35
Minnesota	52	Itasca	8.83	Gravel	Jan. 5	51,409.76	25,000.00
	67	Pennington	3.70	do	Jan. 6	22,781.55	11,390.77
	85	Cottonwood	5.42	do	do	36,285.94	17,000.00
	88	Chippewa	5.01	Gravel	do	51,560.77	25,000.00
	62	Dodge	13.20	do	Jan. 31	53,075.57	26,537.78
Mississippi	77	Jackson	2.64	do	Jan. 12	100,544.73	50,272.36
	40	Monroe	13.965	Gravel	Jan. 29	130,487.69	65,243.84
	44	Lawrence	10.68	Clay gravel	do	49,923.96	24,961.98
Montana	10	Cascade	18.690	Screened gravel	Jan. 6	92,925.96	46,462.98
	23	Blaine	4.25	Gravel	Jan. 29	24,192.96	12,096.48
	16	Rosebud	3.84	do	Jan. 31	21,987.08	10,993.54
	41	Gallatin	5.00	do	do	51,826.52	25,913.26
Nebraska	39	Dawson	27.47	Earth	Jan. 6	110,139.74	55,069.87
	40	Thayer	7.27	Gravel clay	Jan. 17	30,741.37	15,370.68
	74A	Dundy	4.49	Earth	do	27,826.04	13,913.02
	51	Kearney, Franklin	16.19	do	do	61,256.56	30,628.28
	11	Gosper	7.05	do	Jan. 28	38,815.53	19,407.71
Nevada	17	Lyon	5.89	Gravel	Jan. 17	46,310.11	23,155.05
	24A	Churchill	10.42	Gravel, crushed rock	do	104,500.00	52,250.00
New Hampshire	84	Grafton	.....	Bridge	Jan. 6	17,381.21	8,690.60
	85	Merrimack	.473	Gravel	do	4,014.50	2,007.25
	30	Grafton	.427	do	do	5,114.89	2,557.44
	73	Carroll	.785	do	do	14,160.96	7,080.48
	74	do	1.27	W. B. macadam	do	19,319.30	9,659.65
	34	do	.549	do	do	4,929.81	2,464.90
	44	Cheshire	.317	Bituminous macadam	do	12,351.88	6,175.94
	48	do	.24	Gravel	do	20,971.91	9,691.22
	57	do	.539	do	do	12,852.73	6,426.36
	61	do	1.63	do	do	21,192.60	10,596.30
	62	Strafford	.68	do	do	8,158.53	4,079.26
	66	Carroll	1.03	do	do	9,338.39	4,669.19
	72	Merrimack	1.07	do	do	15,174.06	7,587.03
	81	Grafton	.....	Bridge	do	11,964.20	5,982.10
	53	do	3.106	Gravel	Jan. 29	44,692.34	22,346.17
	58	do	1.136	do	do	29,840.91	14,920.45
	49	Belknap	1.09	do	do	9,343.40	4,671.70
New Jersey	15	Middlesex, Union	3.55	Concrete	Jan. 5	142,119.23	71,059.61
	16	Hunterdon	2.137	do	Jan. 6	233,711.12	117,855.56
North Carolina	63	Buncombe	3.68	Macadam	Jan. 29	133,545.32	66,772.66
	76	Cabarrus	1.35	Concrete base: bituminous surface	do	48,633.20	24,316.60
	79	Cleveland	1.645	Concrete or bituminous macadam	Jan. 26	67,063.64	32,900.00
	64	Carteret	13.67	Concrete	Jan. 31	342,497.74	171,248.87
North Dakota	45	Foster	11.10	Earth	Jan. 12	40,289.22	20,144.61
	44	Bottineau	4.51	do	Jan. 5	32,257.65	16,128.82
	34	Emmons	11.69	Grading and draining	Jan. 17	44,767.86	22,383.93
	28	Ransom	17.895	do	Jan. 29	58,547.39	29,273.69
Ohio	39	Auglaize	7.815	Concrete	Jan. 5	282,000.00	70,500.00
	29	Scioto	6.639	Concrete or brick bituminous	Jan. 6	262,000.00	69,000.00
	83	Cuyahoga	9.749	Concrete	Jan. 5	163,349.62	81,000.00
	95	Pouilding	2.997	Brick or concrete	Jan. 29	114,450.00	30,000.00
	101	Adams	6.254	W. B. macadam	do	119,000.00	48,000.00
Oklahoma	10	LeFlore	.....	Bridge	Jan. 12	107,919.43	53,959.71
	13	Pushmataha	.....	do	Jan. 29	12,156.92	6,078.46
	11	Pottawatomie	.....	do	Jan. 31	198,467.79	99,233.89
Oregon	4	Wheeler	9.47	Earth	Jan. 12	55,449.90	27,724.95
	28	Malheur	9.11	Gravel	Jan. 31	73,930.17	36,965.08
South Carolina	21	Edgefield	8.42	Topsoil	Jan. 5	65,077.73	32,538.86
	27	Spartanburg	3.676	do	Jan. 6	34,732.21	17,366.10
	29A	Laurens	14.316	do	Jan. 5	100,149.12	50,074.56
	30	Pickens	5.708	do	Jan. 6	56,793.27	28,396.63
	31	Spartanburg	1.989	Asphalt on concrete base	Jan. 5	57,749.92	28,874.96
	20	Cherokee	9.095	Topsoil	Jan. ..	48,102.28	24,051.14
South Dakota	16	Hughes	17.83	Earth-gravel	Jan. 12	74,476.34	37,238.17
	17	Lake	12.44	Gravel	Jan. 9	115,566.03	57,783.01
	18	Hand	15.03	do	do	140,765.29	70,382.64
	19	Hyde	6.96	do	Jan. 6	66,562.95	33,281.47
	21	Aurora	7.76	do	Jan. 9	69,166.16	34,583.08
Tennessee	8	Shelby	16.04	Bituminous macadam	Jan. 28	361,563.56	180,781.78
Texas	59	Calhoun	10.312	Mud-shell-bituminous surface	Jan. 5	31,679.19	15,804.00
	74	Travis	3.89	Gravel-bituminous surface	Jan. 17	11,429.28	5,714.64
	101	Bowie	14.78	Gravel	Jan. 29	117,168.46	58,584.23
	97	Brazos	10.33	Gravel concrete	Jan. 31	112,950.04	42,752.75
	98	Collin	24.955	Concrete and gravel-bituminous top	do	330,120.91	135,000.00
Utah	4A & B	Emery and Carbon	.37	Grading and draining	Jan. 30	16,407.96	8,203.98
Virginia	53	Fauquier	3.105	W. B. macadam	Jan. 6	62,807.58	31,403.79
	32	Fairfax	3.274	Bituminous macadam	do	64,125.60	32,062.80
	40	Dinwiddie	1.622	Concrete	Jan. 5	41,282.06	20,641.03
	51	Loudoun	4.45	W. B. macadam	Jan. 31	71,353.21	35,676.60
	57	Pulaski	4.07	do	Jan. 29	58,668.06	29,334.03
Washington	44	Clarke	4.03	Concrete	Jan. 17	157,161.30	60,000.00
	45	Chelan	2.155	Gravel	do	91,037.10	43,100.00
West Virginia	67	Berkeley	7.03	Bituminous macadam	Jan. 6	82,840.00	41,420.00
	32	Roane	3.75	Concrete	do	127,294.91	44,104.00
	80	Marshall	.484	Brick on concrete base	do	23,700.00	9,680.00
	17	Brooke	1.00	Brick and bituminous macadam	Jan. 12	40,130.00	7,580.00
	64	Jefferson	5.56	Bituminous macadam	Jan. 29	77,390.00	38,695.00
	76	Brooks	1.00	Bituminous macadam and concrete	do	25,800.00	12,900.00
	79	Pocahontas	5.53	Bituminous macadam, earth	Jan. 26	84,370.00	42,185.00
Wisconsin	73	Mineral	10.486	Gravel	Jan. 31	71,534.00	35,744.00
	45	Ashland	7.931	Earth	Jan. 6	38,998.76	12,999.59
	100	Grant	1.135	do	Jan. 5	27,000.00	9,000.00
	87	Buffalo	3.45	do	Jan. 29	50,787.91	16,929.30
	94	Marathon	4.23	Concrete	do	121,250.85	40,416.95
	95	Milwaukee	1.04	Bridge	do	67,647.14	22,549.04
	92	La Crosse	1.39	Bituminous macadam	do	18,007.50	6,002.50
Total	140		867.05			15,335,788.45	6,947,170.49

# ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

*Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.*

## REPORTS.

- \*Report of the Director of the Office of Public Roads for 1916. 5c.
- \*Report of the Director of the Office of Public Roads for 1917. 5c.
- Report of the Director of the Bureau of Public Roads for 1918.
- Report of the Chief of the Bureau of Public Roads for 1919.

## DEPARTMENT BULLETINS.

- Dept. Bul. 105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
- 136. Highway Bonds.
- 220. Road Models.
- 230. Oil Mixed Portland Cement Concrete.
- 249. Portland Cement Concrete Pavements for Country Roads.
- 257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
- 314. Methods for the Examination of Bituminous Road Materials.
- 347. Methods for the Determination of the Physical Properties of Road-Building Rock.
- \*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
- 370. The Results of Physical Tests of Road-Building Rock.
- 373. Brick Roads.
- 386. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
- 387. Public Road Mileage and Revenues in the Southern States, 1914.
- 388. Public Road Mileage and Revenues in the New England States, 1914.
- 389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
- 390. Public Road Mileage in the United States, 1914. A Summary.
- 393. Economic Surveys of County Highway Improvement.
- 407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
- 414. Convict Labor for Road Work.
- 463. Earth, Sand-Clay, and Gravel Roads.
- 532. The Expansion and Contraction of Concrete and Concrete Roads.
- 537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
- 555. Standard Forms for Specifications, Tests Reports, and Methods of Sampling for Road Materials.
- 583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
- 586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
- 660. Highway Cost Keeping.
- 670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
- 691. Typical Specifications for Bituminous Road Materials.
- 704. Typical Specifications for Nonbituminous Road Materials.
- 724. Drainage Methods and Foundations for County Roads.
- Public Roads, Vol. I, No. 11. Tests of Road-Building Rock in 1918.

## OFFICE OF PUBLIC ROADS BULLETINS.

- Bul. \*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
- \*43. Highway Bridges and Culverts. (1912.) 15c.
- \*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.

\* Department supply exhausted.

## OFFICE OF PUBLIC ROADS CIRCULARS.

- Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
- \*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
- \*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
- \*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
- 98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
- \*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
- \*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

## OFFICE OF THE SECRETARY CIRCULARS.

- Sec. Cir. 49. Motor Vehicle Registrations and Revenues, 1914.
- 52. State Highway Mileage and Expenditures to January 1, 1915.
- 59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
- 63. State Highway Mileage and Expenditures to January 1, 1916.
- 65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
- 72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads.
- 73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
- 74. State Highway Mileage and Expenditures for the Calendar Year 1916.
- 77. Experimental Roads in the Vicinity of Washington, D. C.
- Public Roads Vol. I, No. 1. Automobile Registrations, Licenses, and Revenues in the United States, 1917.
- Vol. I, No. 3. State Highway Mileage and Expenditures in the United States, 1917.
- Vol. I, No. 11. Automobile Registrations, Licenses, and Revenues in the United States, 1918.
- Vol. II, No. 15. State Highway Mileage and Expenditures in the United States, 1918.

## FARMERS' BULLETINS.

- F. B. 338. Macadam Roads
- 505. Benefits of Improved Roads.
- 597. The Road Drag.

## SEPARATE REPRINTS FROM THE YEARBOOK.

- Y. B. Sep. \*638. State Management of Public Roads; Its Development and Trend. 5c.
- 727. Design of Public Roads.
- 739. Federal Aid to Highways, 1917.

## REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

- Vol. 5. No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
- Vol. 5. No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
- Vol. 5. No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
- Vol. 5. No. 24, D-6. A New Penetration Needle for Use in Testing Bituminous Materials.
- Vol. 6. No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
- Vol. 10. No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction.
- Vol. 10. No. 7, D-13. Toughness of Bituminous Aggregates.
- Vol. 11. No. 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.
- Vol. 17. No. 4, D-16. Ultra-Microscopic Examination of Disperse Colloids Present in Bituminous Road Materials.

\* Department supply exhausted.

